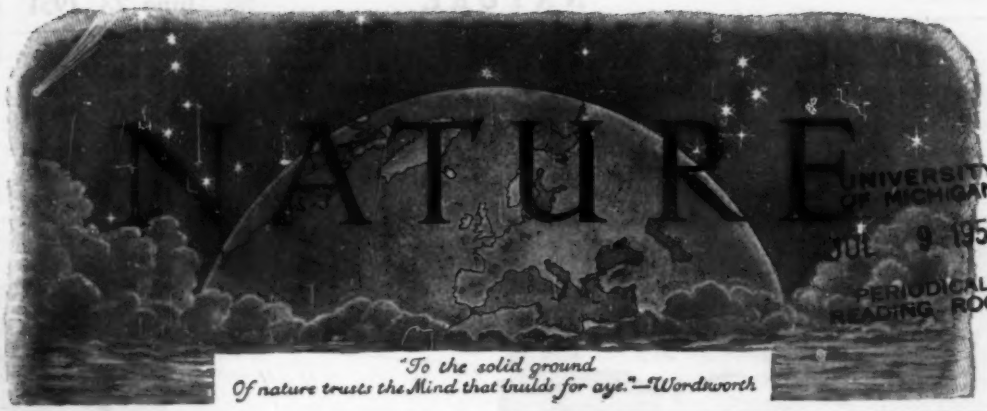

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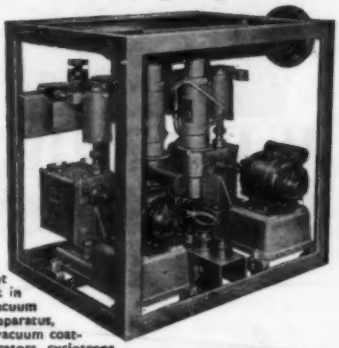

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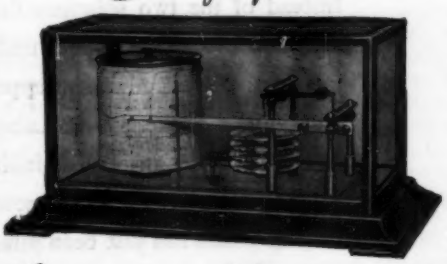

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No. 4260 SATURDAY, JUNE 23, 1951 Vol. 167

CONTENTS

	Page
Planning in Scientific Research	1001
High-Polymer Chemistry. By Prof. H. W. Melville, F.R.S.	1003
Plant Propagation for the Horticulturist	1003
Seaweed Utilization. By Prof. Lily Newton	1004
Thrift Books. By T. H. Hawkins	1004
National Physical Laboratory, Teddington: Annual Inspection and Open Days	1006
Extracellular Photosynthetic Reactions. By Prof. Daniel I. Arnon	1008
The World Land Use Survey. By Prof. L. Dudley Stamp, C.B.E.	1010
Geophysical and Meteorological Changes in the Period January–April 1949. By Dr. W. J. G. Beynon and G. M. Brown	1012
Thomas Wright and Immanuel Kant, Pioneers in Stellar Astronomy. By Prof. F. A. Paneth, F.R.S.	1014
News and Views	1016
Cement and Concrete Association Research Station: Opening of the New Structures Laboratory	1019
Central Building Research Institute, India	1020
Internal Friction of Solids. By G. Bradfield	1021
"White Corridors"	1023
Cambridge University Educational Film Council	1024
Letters to the Editors:	
Masses of Krypton-82, -84 and -86 and Xenon-129 and -132.—Cort L. Kegley and Dr. Henry E. Duckworth	1025
Measurement of Very Low Velocities of Water-flow.—Brigadier R. A. Bagnold, O.B.E., F.R.S.	1025
Angular Distributions of Protons from the Reaction $^{13}C(d,p)^{14}C$.—Prof. J. Rotblat	1027
Height of the Potential Barrier in Contact Rectifiers and its Change with Temperature.—Dr. E. Billig and M. S. Ridout	1028
Derivation of the Dispersion Equation for Alfvén's Magneto-Hydrodynamic Waves from Bailey's Electromagneto-Ionic Theory.—J. W. Dungey	1029
Photoreduction in Algæ.—Albert W. Frenkel and Cecilia Rieger	1030
Amino-Acids of Certain Algæ.—L. Fowden	1030
Various Antibiotics from one Strain of *Streptococcus lactis*.—A. Hirsch	1031
Uptake of Lanthanum by a Yeast.—V. T. Bowen and Ann C. Rubinson	1032
Presence of Enteramine in the Skin of Amphibia.—Dr. V. Erspamer and M. Vialli	1033
Aldolase Activity in Zinc-deficient Plants.—T. A. F. Quinlan-Watson	1033
Vitamin B_{12} as a Growth Factor for Soil Bacteria.—A. G. Lochhead and R. H. Thexton	1034
Formation of C–P Bonds by Addition of Di-Alkyl Hydrogen Phosphonates and Alkyl Hydrogen Phosphinates to Activated Ethylenic Derivatives.—B. Bochwic and J. Michalski	1035
Symmetrical Bi-Aromatics.—Louis J. Owen and Prof. F. F. Nord	1035
Configurational Activity.—Dr. F. P. Dwyer, Miss E. C. Gyarfas and M. F. O'Dwyer	1036
Carbamidine-substituted Pyrazoles.—F. L. Scott, Miss C. M. B. Murphy and Prof. J. Reilly	1037
Adsorption of Water Vapour on Solid Surfaces.—Dr. W. H. J. Vernon, O.B.E.; Dr. James M. Macaulay; Dr. F. P. Bowden, F.R.S., and W. R. Throssell	1037

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PLANNING IN SCIENTIFIC RESEARCH

THE Jubilee Memorial Lecture, "Pure Science, Applied Science, and the Application of Science", which Prof. H. R. Kruyt, president of the International Union of Pure and Applied Chemistry, delivered before the Society of Chemical Industry in London and Manchester last January (see *Chemistry and Industry*, 260, April 7, 1951), will be read with interest not only by those dealing with scientific and industrial research but also by those concerned with the development of technological education and the form which its expansion in Great Britain should take. It is a valuable contribution to clear thinking on these subjects, and all that Prof. Kruyt says about the close relations between pure and applied science supports those who in recent years have urged that industrial progress depends largely on the vigour with which research is pursued in the pure sciences. Even from the point of view of technological development, a first concern should be to ensure that the conditions in which science can be most creative and fruitful are fully safeguarded.

That point is worth making at the present time, when it is being urged with some truth that the immediate need of Great Britain is not new knowledge but the more effective utilization of existing knowledge. That much is recognized, for example, by the Advisory Council for Scientific and Industrial Research; nevertheless, in its report for the year 1948–49 it was concerned about the need for more of the fundamental research on which any long-term progress depends. From the recently issued report for 1949–50 it appears that the Council is still anxious to restore basic scientific research in the departments to the level necessary for the proper discharge of their duties, and for sustaining a reasonable balance between the solution of immediate problems and the provision of knowledge which will be required to solve the problems of to-morrow.

The Advisory Council has not yet been able to review the programmes of all the Government research establishments from this point of view; but it is satisfactory to note from its comments on the work of the Fuel Research Station and the Forest Products Research Laboratory that the present call for the utmost effort to serve immediate national needs has not deflected attention from the long-range work on which progress ultimately depends. Moreover, lecturing last year to the Royal Society (*Proc. Roy. Soc.*, A, 205, 453; 1951), Prof. H. D. Kay, director of the National Institute for Research in Dairying, emphasized that the experience at that Institute also indicated the importance of preserving a balance between the effort devoted to investigations required for the solution of urgent technological problems arising in the industry, and the fundamental research on which future development of the industry might largely depend. Prof. Kruyt in his Jubilee Lecture quoted several examples of the way in which industrial development has depended on the advance of pure science, although

he points out that, as the development of photography showed, the absence of fundamental knowledge did not always halt technical development.

In this part of his lecture, Prof. Kruyt emphasizes that applied science is just as profound as pure science, working along similar lines to reach its goal, and he refutes the notion that applied science is in any way inferior to pure science. It uses the same intellectual method, but applies it in a deliberately chosen direction; and accordingly he suggests that it is better to speak of 'directed' and 'non-directed' science. The non-directed study of reality, seeking to widen our understanding, is the basis of our scientific activity; but in referring to the study of pure science as basic research, it is important not to confuse basic research and fundamental research. Fundamental research is possible in both the directed and the non-directed fields, and commenting on the existence in the Netherlands of two organizations for the development of science, one for applied and one for pure science, Prof. Kruyt maintains that fundamental research belongs to both.

It is clear from the recent report of the Department of Scientific and Industrial Research that this is fully recognized by the Advisory Council; but it is not always so clear that in the work of the Department a further distinction drawn by Prof. Kruyt is always recognized. The application of science, he points out, is something different from applied science: it is not science but doing. The Advisory Council on Scientific Policy in its last two reports has been deeply concerned with the application of science, and this is primarily a matter for industry itself. The Department of Scientific and Industrial Research rightly endeavours to see that the results of its work are widely known and that they reach the quarters where they can be of most service. The Department has certain responsibilities for dissemination of the information; the utilization of the information, however, is a responsibility of industry itself.

It is true that fundamental work in the directed field may be directed towards the wrong objectives, and may lie rather in the non-directed field. That is why intimate contact with industry is so important if a research institute or association is to do effective work. Prof. Kay, in the lecture already noted, lays great stress on this factor of co-operation, especially on an informal basis, and Prof. Kruyt concludes his lecture by discussing further the way in which scientific workers can be related more closely with industry without detriment to the advance of pure science. First, it may be noted that Prof. Kruyt is strongly of the opinion that the universities, rather than independent research institutes, are the natural home of basic research, and that the universities should provide full opportunity for this kind of creative work. Such research should be associated with education, and the continuous stream of students keeps the university young and avoids the dangers of staleness which beset the isolated institute. There is also a further factor noted by Prof. Kay, that no research institute, associated with an industry, can carry out its work satisfactorily unless it is able to bring to bear, simultaneously and whenever necessary, on both *ad hoc* and fundamental problems, the academic and practical lore and the varied approach of several different scientific disciplines. That might, indeed, sometimes be more easily achieved in a research institute than in a university. The factor of size will enter as well as that of internal organization; but adequate opportunities for the cross-fertilization of minds in this way are as essential in pure as in applied science.

While Prof. Kruyt is emphatic that the universities should be the cradle of pure science, he gives no definite guidance with regard to the applied sciences; and his most important contribution to the current debate on higher technological education in Great Britain is to be found in his insistence on the prestige and status of applied scientist or technologist. Whether the latter is trained at the university or in a technological institution or technical college, he is by training as much a scholar as the pure scientist, and like him should be educated in the atmosphere of creative research. Prof. Kruyt's observations on the special institutes for textiles, plastics, hides and leather, etc., suggest that he regards their scope as too narrow to be wisely associated with educational work, and that he may be dubious about the value of some of the institutions on the lines of the newly established national colleges in Britain. It might also be inferred that he would strongly dissent from views such as those embodied in the recommendations of the National Advisory Council on Education for Industry and Commerce regarding the upgrading of technical colleges in general, and would favour the elevation to university status of a few carefully selected colleges with possibly the establishment of a new technological institution of the type of the Massachusetts Institute of Technology. Above all, it is clear that, in his judgment, institutions responsible for the training of the technologist, as distinct from the technician, must be endowed with adequate resources for research, so that the training in applied science can be given in the same creative atmosphere of research as the training in pure science at the universities; and he would probably agree with N. J. Petch's remark, in the April issue of *The Universities Quarterly*, that the conduct of technological research in the universities is not only good for teaching but also helps to attract science graduates into technology.

It might perhaps be argued that Prof. Kruyt has overlooked a certain difference in atmosphere between pure and applied science; but his distinction between 'directed' and 'non-directed' research really stresses the essential point which was also made by Dr. B. A. Keen in his presidential address to the Nairobi Scientific and Philosophical Society two years ago. Dr. Keen had suggested that the best returns have frequently come from those whose work has diverged most from the programme planned, and that there is a real danger that the very prestige of the individual members of an advisory council might lead to their advice on research matters being construed as directions. It is not easy, he said, to avoid

the sense of frustration which might arise out of delay in dealing with representations in such circumstances, and Dr. Keen is convinced that the rightful sphere for planning and organization is in the technological stage. Even so, the plan should in general be prepared by a local body, familiar with the problems and priorities and local conditions. In fundamental research, organization and planning, except in the very broadest general terms, are, in his opinion, useless. "Research," as the late Sir Daniel Hall said as long ago as 1927 to the Imperial Agricultural Research Conference, "is after all a product of the individual. It is a matter of imagination and intuition . . . and no administrator, no organization, can of itself turn it out."

HIGH-POLYMER CHEMISTRY

Physical Chemistry of High Polymeric Systems

By H. Mark and A. V. Tobolsky. (High Polymers, Vol. 2.) Pp. xi+506. 52*s*.

Natural and Synthetic High-Polymers

A Textbook and Reference Book for Chemists and Biologists. By Prof. Kurt H. Meyer. (High Polymers, Vol. 4.) Pp. xx+891. 120*s*.

Second completely revised and augmented editions. (New York and London: Interscience Publishers, Inc., 1950.)

THESE two volumes are second editions of volumes dealing with important aspects of high-polymer chemistry. Both were first published nearly ten years ago, and it is therefore interesting to see what progress has occurred in a period of considerable activity in this field of chemistry. In spite of very striking advances, the pattern of these books has remained essentially unchanged. This reflects the farsightedness of the authors in mapping out the most likely fields in which further advances were likely to occur. Fortunately, the authors have contrived to incorporate the new knowledge without too large an increase in the size of either volume.

The first work, Vol. 2 of the series, is really more a book on physical chemistry required for the understanding of high-polymer chemistry than a book on high-polymer chemistry itself. In preparing this new edition Prof. H. Mark has had the collaboration of Dr. A. V. Tobolsky. It includes a great deal of molecular structure, thermodynamics and kinetics treated in a rather unusual and therefore useful way, which should be of considerable interest to those readers not specially interested in high polymers. In the sections on structures a large amount of new material has accumulated. The important new developments are skilfully blended with the principles of the subject. The main emphasis is still on the basic principles, because one object of this volume is to provide a rational description of these principles so that the other volumes can be all the more readily understood and appreciated. Similarly, in the section on the behaviour of high-polymer solutions, much clarification in this field has been achieved, although the basic pattern remains. The largest new section is that dealing with the kinetics. Here a minor revolution has occurred, and the whole subject has become quantitative and exact, and therefore takes its place along with thermodynamical treatments of high-polymer solutions in a much improved form and perspective. A completely new chapter on the degradation of high polymers has been added.

In the second book, Vol. 4 of the series, by Prof. K. H. Meyer, the object is rather different. Natural and synthetic high polymers, with the main emphasis on structure, are dealt with in an individualistic way which is to be expected. There is, naturally, some overlap of subject with other volumes of the series; but the authors' points of view are usually so different that nothing is lost by looking at high-polymer chemistry—especially the more controversial fields—in a number of ways. In this volume, too, the pattern is unchanged; but at every point there is included new knowledge of the past decade. There is, naturally, a much extended section on rubbers, and the section on polysaccharides is thoroughly revised and to some extent rearranged. Due notice is taken of the new knowledge in starch chemistry and other fields of polysaccharide chemistry. In the section on protein chemistry all the major advances are recorded, and there is a good deal of rearrangement. Dr. A. J. A. van der Wyk has collaborated with Prof. Meyer in revising a much-extended section on high-polymer solutions and the mechanical properties of high-polymer substances. All this new treatment has been incorporated by the addition of only two hundred pages to the volume, which is the minimum that could probably be achieved.

The printing and binding of both the books are up to the high standard expected in this series. Unfortunately, the expansion has resulted in an increase in price.

H. W. MELVILLE

PLANT PROPAGATION FOR THE HORTICULTURIST

The Propagation of Plants

By E. J. King. Pp. 264. (London: Hutchinson's Scientific and Technical Publications, n.d.) 16*s*. net.

IN this book the author has condensed into a small compass a vast amount of information concerning the propagation of plants. Information which is widely scattered in scientific monographs, botanical text-books, commercial handbooks and similar publications has been brought together by the author. He has simplified this mass of detail, integrated it with knowledge gained from his own wide practical experience and has presented it in a concise, readable form easily understood by the intelligent amateur gardener. But the book does not consist merely of a description of rule-of-thumb methods of propagation; the botanical principles underlying the art and science of propagation are also clearly explained.

The contents are divided into two parts, the first dealing with "Propagation by Seeds", and the second, and much larger, section with "Vegetative Propagation". The former section covers a wide range of subjects, from the preparation of the seed-bed to the harvesting of home-saved seed; and, in the chapters devoted to vegetative propagation, all the standard methods used by horticulturists are described and, in some cases, illustrated by line drawings.

The author also discusses briefly the newer methods of propagation involving the use of plant hormones, but he has omitted to include other modern methods now in general practice; for example, in the section dealing with the raising of orchids from seed, there is no mention of non-symbiotic germination. The com-

prehensive lists given at the end of Part 1, of plants which can be raised from seed, and the classified alphabetical lists of plants, with information about the suitable vegetative method of increase of each, are most useful.

The chapter on the propagation of ferns is very welcome, for published information on this subject is very scattered. It is unfortunate that the author has used an invalid botanical name for the male fern, and has described the compound pinnate frond of *Woodwardia radicans* as long and entire and "not dissimilar from that of our native harts-tongue". However, a few errors are inevitable in a book of this size, which as the author states "is intended to combine something of everything in a small compass without loss of standard", and the number of inaccuracies is remarkably small.

The somewhat unusual arrangement of the text in numbered paragraphs is excellent for precise reference, and the entries in the very full index are based on these numbers. This little book should prove a veritable vade-mecum to the amateur gardener and to many of the smaller commercial growers. Botanists and teachers of the science and practice of horticulture will also find in it much of interest.

SEAWEED UTILIZATION

Seaweeds and their Uses

By Prof. V. J. Chapman. Pp. xiv+287+20 plates. (London: Methuen and Co., Ltd., 1950.) 25*s*. net.

IN this work Prof. V. J. Chapman has attempted to bring the available information into the compass of a single volume, to make it acceptable to the general reader and sufficiently comprehensive to be of value to the specialist. The task was obviously difficult, and he is to be congratulated on the amount of information that he has made available.

The author's preface is perhaps unnecessarily doleful, as indeed his subsequent chapters show, and some of the statements he makes in the preface are of so sweeping a character that one hesitates to accept them without further consideration. For example, on p. ix he writes: "The spread of civilisation with its greater range of foods is slowly eliminating the use of seaweeds as human foods, even in such strongholds as Japan and Hawaii. One must therefore accept the fact that the present known types of edible algæ will never again achieve a wide use." According to the report of E. J. Ferguson Wood on the uses of seaweeds in Japan, soon after the close of the Second World War, the addition of brown seaweeds to the flour was obligatory in many prefectures, and there appears to be every indication that the Japanese seaweed industry is rapidly recovering. Many seaweeds have a high protein and carbohydrate content and are therefore a potential source of food, if it could be converted into a form that is readily assimilable by humans. With the present numerical state of the world's population, when further sources of food are urgently needed, one wonders whether the second sentence in the quotation is not a pre-judgment of what may become an important issue.

The book contains nine chapters, which deal successively with the occurrence and distribution of seaweeds, with historical aspects of seaweed utilization and with accounts of different industries which have assumed importance from time to time. The last chapter discusses the location of the world supplies and the methods of harvesting.

War-time difficulties have hampered Prof. Chapman in the publication of the book, and an addendum summarizes some of the more recent work. The inclusion of an extensive bibliography greatly enhances the value of the book.

There are fifty-two illustrations in the text, some of which appear to lack just the right mode of delineation of the plant. For example, the inclusion of the characteristic fruiting pustules would have made the drawings of *Chondrus crispus* on p. 11 much more convincing. The relative size of *Fucus serratus* and *Himanthalia lorea* on p. 7 is misleading to the uninitiated, and it seems a pity that the picture of *Fucus vesiculosus* on p. 5, so profuse in its bladders, should lack receptacles. The twenty plates at the end of the volume depict various aspects of seaweed harvest and manufacture and are of considerable interest.

LILY NEWTON

THRIFT BOOKS

Evolution in Outline.

By Prof. T. Neville George. (Thrift Books, No. 1.) Pp. 126. (London: Watts and Co., Ltd., 1951.) 1*s*. net.

What's all this about Genetics?

By Rona Hurst. (Thrift Books, No. 3.) Pp. 124. (London: Watts and Co., Ltd., 1951.) 1*s*. net.

The Ladder of Life from Molecule to Mind

By A. Gowans Whyte. (Thrift Books, No. 4.) Pp. 120. (London: Watts and Co., Ltd., 1951.) 1*s*. net.

THE continuing success of the Thinkers' Library series over the past twenty-two years has impelled its publishers to launch a companion series called Thrift Books. Four of these have now been published, one dealing with theatre-going and the three under review with biological topics. Each is a new book specially written for the series and, in these times, the series offers remarkable value for money.

"Evolution in Outline" is a concise account of organic evolution by an acknowledged expert who examines the merits and deficiencies of various theories. Whether the closely knit and sparsely illustrated text will be popular with the general reader, whose taste has been accustomed to the lavishly produced periodicals and books on biological topics which have so freely appeared in recent years, is open to question.

Mrs. Hurst's book, on the other hand, will present little difficulty to the 'ordinary reader' for whom it is intended; the inclusion of relevant biographical details about famous investigators illuminates her account of important discoveries in genetics and quickly captures interest.

Gowans Whyte in his book describes the development of mind through the biological ages. His skilful selection from the writings of leading authorities in neurology and psychology are carefully interpolated to support his argument and win the attention of the reader; this he succeeds in doing.

If the standard of these three books is maintained in later volumes of the series, the publishers of Thrift Books may be content that they have not only increased the range of scientific knowledge but also extended the rational attitude of scientific investigators among the general public.

T. H. HAWKINS

Carnegie Institution of Washington

Publication 589: Maya Hieroglyphic Writing; Introduction. By J. Eric S. Thompson. Pp. xvii+347+64 plates. (Washington, D.C.: Carnegie Institution, 1950.) 7 dollars.

THIS work is a very profound study of a very difficult subject, which appeals primarily to specialists. Nevertheless, it is written with such a background of knowledge of the Maya, both those who survive and those long dead, that no student of American archæology can afford to neglect it. Eric Thompson has studied the Maya for nearly twenty-five years and has long been known as one of the foremost authorities on their hieroglyphic writing. This book will consolidate and increase his reputation.

The book contains a wealth of detailed information about the various types of Maya inscription, those cut on stone, and those painted in the manuscripts and to a lesser extent on wall or pot. Each of the great synchronized cycles which make up the calendar is considered, and much new light is also thrown on divinatory inscriptions. All this reveals the extraordinary complexity of the subject, but the treatment is lightened by the author's constant insistence on human and spiritual factors and by the happiness of his style. He says, in effect, that mathematics and astronomy have an essential part in this study, but that an understanding of Maya religion and mythology is more important; and he goes so far as to state that "Mysticism, religion and poetry completely dominate their hieroglyphic writing". It is emphasized that the whole of Maya religion revolves around the majestic conception of the eternal march of time, in which the periods into which the calendar is divided are borne along by the gods, who pause only to change over like relay runners at the appropriate period endings. This is graphically shown on the most elaborate form of inscription, the full-figure glyphs exemplified by Stela D. at Copan, of which a free modern version forms the frontispiece.

The study of Maya glyphs has few adherents in Great Britain, so this review has been deliberately kept short; but its brevity is no measure of the importance of the work, which, in its own field, can scarcely be exaggerated. G. H. S. BUSHNELL

A History of Philosophical Systems

Edited by Prof. Vergilius Ferm. Pp. xv+642. (New York: Philosophical Library, Inc., 1950.) 6 dollars.

IN this work forty-seven short articles by forty-one different authors on special philosophical subjects, for example, platonism, the philosophy of the enlightenment and existentialism, have been well printed, placed between boards and decorated with Rodin's "Penseur" on the dust cover. All the same, it has not made a good book, and it is scarcely history. As articles in an encyclopædia, along with other related articles and cross-references, they would have their use. For the period up to the end of the eighteenth century the ground is fairly well covered, except for political theory. For more recent times the subjects are selected on no recognizable system; there is repetition and there are gaps. Some articles are rather perfunctory, with inadequate bibliographies; others are careful, scholarly summaries of their subjects, with well-selected bibliographies.

The article on "Semantics", by Prof. Gustav Bergmann, is a well-directed attack on fashionable theories about language, showing that even if they have some limited technical validity, they are of no philosophical interest. I would willingly give half the price of the book for this article, because it accords with my prejudices, and perhaps less willingly the other half for three of the others. Most students of philosophy and most librarians, on their behalf, will do well to spend their six dollars on something else. A. D. RITCHIE

New Biology, 10

Edited by M. L. Johnson and Michael Abercrombie. Pp. 144+31 plates. (Harmondsworth: Penguin Books, Ltd., 1951.) 1*s.* 6*d.*

THE latest of the "Famous Animals" to be described in "New Biology" is *Amœba*. The description appears in the tenth issue, and in it Michael Swann has collected up-to-date information about the nature of the plasmalemma, the mechanics of pseudopodial movement and the genetic constitution of amœba; the article is a worthy successor to previous ones which dealt with *Hydra* and the tapeworm. Another valuable article in this issue of "New Biology" is one by John Carthy on instinct, which surveys the contemporary field with particular reference to the work of Tinbergen and Lorenz on "releasers". Other topics considered are the biological application of isotopes, apple scars and blemishes, and mimicry in the British fauna. An account is also given of observations made by Richard Perry on the gannet during his stay on the small island of Noss in the Shetlands in 1946 as well as of some recent inquiries by G. E. Fogg into the wetting of leaves by water, a subject of increasing agricultural importance now that more and more liquid sprays are being developed. In addition to some useful diagrams, this issue of "New Biology" contains thirty-one supplementary photographs as well as an index and a list of contents of all previous issues. Once more "New Biology" may be commended as a credit to editors and publishers alike.

Catalogue of Lewis's Medical, Scientific and Technical Lending Library

New edition, revised to December 31, 1949. Pp. xii+1152. (London: H. K. Lewis and Co., Ltd., 1950.) 35*s.* net; to Library subscribers, 17*s.* 6*d.* net.

LEWIS'S Lending Library was established in 1848 mainly to supply the needs of the medical profession but also to lend out books of scientific or philosophical interest not to be found in the ordinary circulating libraries. Later, to meet the requirements of those engaged in the research departments of industrial organizations, the scope of the library was considerably extended to include a wide range of technical subjects; the value of this service is reflected in the large number and variety of industrial organizations which use the library to-day. An important feature of the library is that each book in it is the latest revised edition; when a new edition appears all library copies of the previous edition are withdrawn. The catalogue of the library is classified under the three headings of authors and titles, an index of subjects with the names of authors who have written upon them and an alphabetical list of subjects; the arrangement is such that reference is made both interesting and easy. At present the catalogue contains about 27,000 titles, the total number of volumes in circulation in the library being more than 90,000. For the service the library offers the subscription rates are remarkably low.

NATIONAL PHYSICAL LABORATORY, TEDDINGTON

ANNUAL INSPECTION AND OPEN DAYS

ON May 23, the National Physical Laboratory was inspected by members of its General Board, and a series of 'open days' began which continued until May 29. More than six thousand visitors took advantage of the first opportunity since May 1949 of seeing the widely varied work being carried on. In January of last year the 'N.P.L.' was fifty years old, and this, with the wider celebrations of the Festival of Britain, gave special significance to the 'open days' and the two-day symposium on standards which preceded them. The weather was good, and bright sunshine made the Laboratory and its gardens particularly attractive. There were three hundred and eighty-two exhibits altogether, of which it is possible to mention here only a few.

In the High Speed Laboratory of the Aerodynamics Division, a new tunnel was shown which has a working section 18 in. × 14 in. and can be run at subsonic speeds and at supersonic speeds up to 1·6 times that of sound. The pressure can be varied between one and three atmospheres absolute, so that investigations can be carried out into the effects of using reduced-scale models.

Three exhibits showed the methods of investigation which the Laboratory used in its work on behalf of the Ministry of Transport on the proposed Severn Suspension Bridge: a series of sectional models showed how the latest top-deck design with four separate roadways evolved from the suggested mid-deck forms. The methods of measuring the wind forces on a part model were demonstrated, and a complete flexible model bridge was shown which had been tested in a specially designed wind tunnel at Thurleigh (Beds.) to confirm the results of tests on the sectional models.

There was an alarming 'chamber of horrors' in the Engineering Division, in the form of a display of failures in service which had been sent to the Division from time to time for investigation. Almost invariably, the firms had suggested that the material had been at fault, only to be told by the Division of some defect in construction, such as sharp corners in a keyway or a poor surface finish, which had, in fact, caused the failure.

The Engineering Division as such will cease to exist this summer, when much of the equipment and work is to be transferred to the Mechanical Engineering Research Laboratory at East Kilbride, near Glasgow. There was particular interest, therefore, in a historical exhibit which traced the development of the Division and showed how it had taken the lead in various items of research work, such as road and hydraulics research, which had since developed to the extent that entirely new divisions of the Laboratory and stations of the Department of Scientific and Industrial Research had been formed to further them. The study of fatigue has always been one of the Division's responsibilities, and a repeated-impact testing machine dating from about 1905 was on display. As a contrast, the multiple-unit direct stress-fatigue testing machine recently designed in the Division was also shown. This subjects twenty-four miniature test pieces simultaneously to repeated tensile loading at 3,000 cycles a minute.

The Electricity Division is now testing electrical instruments up to 30 kc./s. by comparison with standard electrostatic instruments. Power of the order of a milliwatt is generated by a stable oscillator and amplified up to 200 watts by two amplifiers. By the use of considerable feedback in the amplifiers, the power output is made extremely stable. Measurement errors are liable to arise principally from capacitance currents. The quadrant and voltage-dividing resistances are wound with fine wire in such a way as to make the residual inductances and capacitances as small as practicable. Shunt capacitance circuits are provided so that the capacitance currents taken by the electrostatic instruments do not pass through the resistances and cause errors.

Two more amplifiers are at present under construction designed to increase the total available output to 400 watts.

In the basement of Bushy House, the Division showed the equipment by which the standard frequencies transmitted daily from the General Post Office station at Rugby are automatically compared with the National Physical Laboratory frequency standard and recorded. A twin-channel electronic switching unit designed and made at the Laboratory allows up to eight different frequencies to be compared in one cycle of operation lasting three minutes; the unit is switched automatically to the next position at the end of each. A record of frequency differences is obtained on a chart recorder, and variations of less than 1×10^{-9} can be detected.

In the Electronics Section, the pilot model of the Laboratory's electronic digital computer (ACE) was shown, operating at the rate of 30,000 additions or 500 multiplications per second. Another item demonstrated, by relays and signal lights, that the error-producing effects of noise in a communication channel can be reduced by including a suitably coded redundancy of information in the transmitted message. By means of lights representing the binary digits 0 and 1, a relay-operated working model showed the sequences of 6-digit patterns that arise when various prescribed functional relations exist between the value of a given digit and the preceding values of two digits of the set.

Water occurs in great quantities in the surface layers of the earth as fresh or sea water, or as moisture in soil, thereby playing a large part in the determination of the characteristics of ground-reflected waves. It also occurs as rain in the atmosphere, and so affects the performance of centimetre-wave radar equipment, because of the absorption and scattering of radiation to which it gives rise at wave-lengths less than about 10 cm. A knowledge of the dielectric properties of water is thus clearly of importance in the study of radio wave propagation. The Radio Division demonstrated the measurement of the dielectric properties of water, salt solutions and methyl and ethyl alcohols at centimetre and millimetre wave-lengths, at frequencies in the range 10,000–50,000 Mc./s.

Another exhibit was an automatic atmospherics wave-form recorder which was built to determine what accuracy may be obtained in the location of thunderstorms by distance measurements made from echo-type wave-forms. For purposes of comparison, the recorder is linked with the Meteorological Office network of direction finders. The wave-form technique may possibly enable thunderstorms to be located from a single station and so lead to an economy in staff.

A new exhibit from the Light Division was a photoelectric colorimeter. A spectroscope is used to spread the colour into a spectrum, and a variable template placed in the plane of the spectrum is adjusted to make the response of the combined spectroscope and photocell match that of the average human eye. Colours are thus measured as they would be with an ordinary trichromatic colorimeter and a human observer, but with more accuracy and precision.

In the original model a single spectroscope was used. To eliminate the error caused by stray light, a commercial instrument of the same type has employed a double spectroscope. In the instrument at the National Physical Laboratory, the light beam has been reversed so that the same dispersing prism is used over again to purify the light. This device, in addition to avoiding the need for two prisms, produces an extra image of the spectrum which allows the use of an exploring slit and so makes the setting and checking of the template easier.

A recently developed process for producing diffraction gratings was also demonstrated in the Light Division. It consists of cutting a very fine screw thread on a cylinder and then 'opening out' the helix upon a flat surface by a plastic replica process. These threads of very fine pitch are cut by a diamond on cylinders of good surface finish, by means of additional reduction gearing to a small screw-cutting lathe. This part of the work is carried out in the workshop of the Metrology Division, and threads as fine as 15,000 per inch have been produced. The inevitable periodic errors in the fine screw threads are then removed by applying the 'Merton nut', a nut lined with a resilient material such as cork, by means of which, on the opposite end of the cylinder, a second thread is cut of extreme regularity. This second, corrected, helix can then be made into a plane grating by a replica process which, when applied to existing plane gratings, has been found to have a fidelity approaching the Rayleigh limit.

The Metrology Division demonstrated a method of autographic testing which provides a continuous record of the errors of precision lead-screws, rather than a series of measurements taken at discrete points along the helix. The test is made in the Laboratory's standard lead-screw lathe, on which the screw is mounted so that it is supported and driven between centres, with the feed of the lathe saddle set to correspond with the nominal pitch of the screw. A small stylus wheel mounted on the lathe saddle engages with the thread of the screw, and errors in the helix of the screw are revealed by axial displacements of the wheel. These are detected by an electromagnetic measuring head and, after electronic amplification, are recorded at a magnification of 1,000. In this way a continuous autographic record of the errors of the screw is obtained along its complete length. The method has the additional advantage that the test can be performed quickly.

Commercially-produced discharge lamps were on show which emit monochromatic rays suitable for high-precision measurements of length by optical interferometry. These lamps contain a small quantity (1 mgm. or less) of a mercury isotope, prepared by irradiating gold in one of the atomic piles at Harwell; usually a little argon gas is added to give stability to the discharge. Comparisons of samples of the lamps show that the wave-lengths of the rays emitted are reproducible to 1 part in 100 million, provided that the pressure of the argon is the same. Direct measurements of length up to nearly 50 cm. (18 in.) are possible, and it has been suggested that the wave-length of the green ray could serve as the ultimate standard of length.

Experiments are also in progress on the application of radio waves to the measurement of length or of the velocity of propagation of electromagnetic radiation or light by interferometry. Waves of length 1·25 cm., generated from a stabilized klystron oscillator, when directed into a suitable interferometer display characteristic interference phenomena similar to those of light waves. As the radio wave-length is about 20,000 times longer than the average wave-length of visible light, the interferometric procedure for measuring lengths of several metres is much simpler with radio waves than with optical waves.

The Division has for a long time collected information on the stability under good atmospheric conditions of analytical weights of various materials, and has now exposed a selection of 100-gm. weights to accelerated corrosion and stability tests in five representative chemical laboratories. For stability of mass, there is apparently little to choose between weights of austenitic stainless steel (25 per cent chromium, 20 per cent nickel), non-magnetic nickel–chromium (80 per cent nickel, 20 per cent chromium), and good rhodium-, platinum- and chromium-plated weights having a nominal thickness of plating of about 0·015 mm. (0·0006 in.) or more. Chromium-plated weights retained their appearance better than any, except perhaps those of highly-polished stainless steel and nickel–chromium, but they are open to the objection that the underlying nickel is slightly magnetic. No kind of weight appeared to be much more suited to one laboratory than to another. An incidental outcome of the tests is a clear indication that lead ought never to be used for the adjustment of screw-knob weights, whether they are likely to be exposed in corrosive atmospheres or not.

Exhibits in the Metallurgy Division showed the extreme similarity in the tensile properties of various copper alloys of which the composition had been adjusted to give equal electron-atom ratios. Others demonstrated the properties of iron alloys of very high purity and brought out particularly the great influence exercised on mechanical properties by small amounts of elements which dissolve interstitially. Photographs illustrated the microstructure of polished aluminium specimens during the process of creep, and an analysis of the various types of displacement had been carried out by means of the phase-contrast microscope and the interference microscope.

Tests in waves were in progress in the No. 1 Tank in the Ship Division on a wax model of a proposed new passenger ship, and in the No. 2 Tank measurements were being carried out on the friction drag of a plane glass surface 7 ft. long. There was also on view a 50-ft. plank, the resistance of which had been measured by the momentum-loss method using a large bank of pitot tubes, four lines of twenty-five tubes each, just behind the trailing edge.

The carriage of No. 2 Tank has been completely overhauled mechanically and electrically since the last 'open days' in 1949, and a storage pond for the wax models has been built. A new model-cutting machine has also been installed.

A new exhibit in the Photometry Section of the Light Division was the apparatus used for the primary standard of light. This standard is a Planckian radiator at the temperature of solidifica-

tion of platinum. The actual radiator used is a small thin-walled hollow cylinder of thoria immersed in an ingot of platinum contained in a crucible of the same refractory material. The ingot is heated by eddy currents generated in it by means of a high-frequency induction heater. Tungsten filament sub-standard lamps are calibrated by comparing them with the radiator during the time the platinum is solidifying. While this process is taking place, the ingot and therefore the radiator are at a constant known temperature, and hence the latter has a definite and readily reproducible luminous intensity per unit area. This standard was adopted internationally in 1948 as the Primary Standard of Luminous Intensity, and the corresponding unit of luminous intensity, the 'candela', is the intensity of one-sixtieth of a square centimetre of the interior of the radiating cavity. It differs from the earlier unit, the International Candle, by less than 2 per cent.

The 'equal-loudness' contours, which relate the intensities of pure tones at different frequencies when the sounds are judged equally loud, are fundamental to the acoustics of hearing, but considerable discrepancies exist between the classical determinations. The National Physical Laboratory has undertaken a new determination, to help to resolve these discrepancies and in the hope that the data will assist in providing a basis for an internationally accepted set of curves. This investigation, in which a 'free-field' method is being adopted with a variety of improvements in technique, is now under way in the Physics Division.

An adiabatic calorimeter for the measurement of the specific and total heats of metals up to high temperatures, about 1,600° C., was also shown in the Physics Division. The sample is placed in a pot of pure sintered alumina which is surrounded by radiation screens of platinum and by an outside enclosure kept electrically at a temperature as close as possible to that of the sample. The rise in temperature of the sample when known amounts of heat are added is measured by thermocouples. The whole apparatus is mounted in a vacuum tank. From work carried out with this equipment it will be possible, for example, to calculate the best cooling cycle for a steel ingot by which it may be brought to working temperature without internal strain. For a large ingot, hours and even days may be saved by such knowledge.

Two types of precision measurements of elastic constants at ultrasonic frequencies were shown. In the first, a short pulse of shear or compression waves at perhaps 5 Mc./s. is timed through the specimen; a precision in timing of $\pm 0{\cdot}002$ microsecond is often possible, so that useful accuracy may be obtained from quite short specimens. In the second, the resonant frequencies of a cylindrical specimen are precisely identified; a magnetostrictive drive and detector are employed. The two methods are complementary and are being used to study the variation of elastic constants with composition of alloys.

Industrial visitors particularly found a good deal to interest them in the Test House, where they watched the routine testing of clinical and meteorological thermometers, barometers, viscometers, volumetric glassware, hydrometers and engineers' small tools.

Short talks on various aspects of the Laboratory's work and on particular items of research were given each afternoon in the recently equipped lecture hall.

EXTRACELLULAR PHOTOSYNTHETIC REACTIONS

By Prof. DANIEL I. ARNON

Division of Plant Nutrition, University of California, Berkeley

ONE of the widely accepted tenets of plant physiology is that photosynthesis is intimately associated with the integrity of green cells. Disruption or even injury to the intact cell leads to the cessation of the process. This view has been based on the failure, for almost three-quarters of a century, of the many attempts to reproduce photosynthesis outside the living cell. The early experiments have often sought to attain an objective which has been aptly characterized as alchemistic in the light of modern knowledge: the performance by broken or dead cells or even by chlorophyll solutions of the process of photosynthesis *in toto*, that is, the utilization of light energy for the reduction of carbon dioxide and the simultaneous evolution of oxygen. However, these early attempts were not wholly negative. Although complete photosynthesis was never reproduced *in vitro*, some of the early experiments of Haberlandt[1], Ewart[2] and Molisch[3] indicated that certain cell preparations retain a limited capacity for oxygen evolution under the influence of light. The full significance of these observations did not become apparent until Hill[4] showed by independent biochemical methods that chloroplasts removed from living cells retain for an appreciable period of time that part of the photosynthetic apparatus which is responsible for the evolution of oxygen under the influence of light in accordance with the general equation:

$$A + H_2O \xrightarrow[\text{chloroplasts}]{\text{light}} H_2A + \tfrac{1}{2}O_2, \qquad (1)$$

in which A represents a hydrogen acceptor other than carbon dioxide.

The photolysis of water by isolated chloroplasts with the concomitant evolution of oxygen, known as the 'Hill reaction', falls short of being a complete photosynthetic reaction in that carbon dioxide cannot serve as the hydrogen acceptor A in reaction 1. The non-participation of carbon dioxide was confirmed by Brown and Franck[5] and Aronoff[6] with the sensitive tracer technique using carbon-14 dioxide. The hydrogen acceptors which have been found effective were substances such as ferricyanide and quinone, which are generally considered foreign to the metabolism of the cell.

These facts were rather puzzling. The Hill reaction has demonstrated the extracellular viability of not only that part of the photosynthetic apparatus which is responsible for the use of light energy for the splitting of water, but also of the cellular components involved in the initial transfer of hydrogen to a suitable acceptor. Why did the hydrogen transfer by isolated chloroplasts fail to accomplish the reduction of carbon dioxide? To answer this question it was postulated that the isolated chloroplasts lack either the appropriate hydrogen carriers or enzymes, or both, required for the reduction of carbon dioxide by the hydrogen derived from the photolysis of water, and that in the intact cell these factors are found chiefly or wholly outside the chloroplasts.

Support for this view was found in the work of Frenkel[7], who presented strong evidence suggesting that the early transformations of carbon dioxide in the intact cell take place outside the chloroplasts. This hypothesis suggests a rather straightforward experimental approach: the use of entire leaf macerates instead of isolated chloroplasts for the extracellular photosynthetic fixation of carbon dioxide. This approach, however, did not seem promising, not only because of the many failures reported by earlier investigators, but also because of recent evidence[8] that the stability of the photolytic system in isolated chloroplasts undergoes rapid deterioration when they are stored, even at low temperatures, in contact with the cytoplasmic fluid. It appeared likely that the disruption of the cell upset the existing equilibria and made conditions favourable for the rapid disintegration of the photolytic activity of chloroplasts by agents residing in the cytoplasm.

It was decided to attack the problem of extracellular photosynthesis by a more circuitous route: the exploration of the reactions and enzymatic composition of chloroplasts and other cellular components, with the view of reconstructing eventually a system of cellular fragments which would be capable of performing certain photosynthetic reactions *in vitro*. The main emphasis was placed on two fractions, chloroplast fragments and 'cytoplasmic fluid', which were separated by high-speed centrifugation after breaking the cells of green leaves[9]. These studies led to the localization of certain enzymes in chloroplasts and helped to elucidate some of the properties and factors governing the extracellular reactions of chloroplast fragments both in the light and in the dark[9,10].

Of special interest in the study of the enzymatic composition of leaf preparations was the occurrence of enzyme systems capable of reductive fixation of carbon dioxide. An enzyme of this kind is the 'malic' enzyme isolated from animal tissues by Ochoa, Mehler and Kornberg[11] and, very significantly, shown to be widely distributed in a number of plant tissues by Conn, Vennesland and Kraemer[12]. The enzyme is specific towards triphosphopyridine nucleotide (co-enzyme II), *l*-malic acid and pyruvic acid. In the presence of manganese the enzyme catalyses reversibly the synthesis of malate by the reductive carboxylation of pyruvate in accordance with reaction 2:

$$\text{Pyruvate} + CO_2 + \text{co-enzyme II.H}_2 \xrightleftharpoons{Mn^{++}} \textit{l}\text{-malate} + \text{co-enzyme II.} \quad (2)$$

Although the equilibrium of reaction 2 is far to the left, it was shown by Ochoa *et al.*[11] that it can be shifted to the right, that is, in the direction of carbon dioxide fixation, by coupling with a suitable hydrogen donor system which would reduce the co-enzyme II. These workers accomplished this by linking the 'malic' system with the glucose-6-phosphate dehydrogenase system. It was apparent that if the 'malic' enzyme could in a similar manner be linked with the hydrogen transfer resulting from the photolysis of water by isolated chloroplasts, a photosynthetic reaction could be reconstructed with the use of fragments of green cells.

The initial experiments to test this possibility were concerned with the localization of the 'malic' enzyme

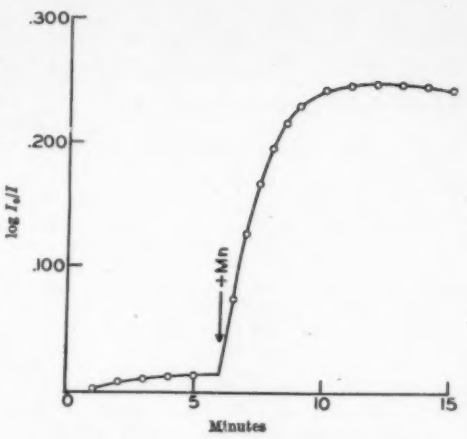

Fig. 1. Activity of 'malic' enzyme prepared from cytoplasmic fluid of sugar beet leaves, as measured spectrophotometrically at 340 mμ by reduction of oxidized co-enzyme II. 'Corex' cells, $d = 1{\cdot}0$ cm. Reaction mixture included 1 ml. tris buffer, 10 micromoles of *l*-malate, 0·18 micromole co-enzyme II, 0·2 ml. 'malic' enzyme preparation and water. Total volume 3 ml. Arrow indicates addition of 2 micromoles manganous chloride to start reaction. The blank cell contained no co-enzyme II. Temperature 20–21° C. pH 7·2

within the leaf. Sugar beet and sunflower plants were grown in nutrient solutions, and large, healthy leaves were macerated and the fragments of chloroplasts separated from the cytoplasmic fluid by methods previously described[9,9]. The 'malic' enzyme activity was tested by the spectrophotometric test used by Ochoa *et al.*[11] modified to include tris aminomethane rather than glycylglycine buffer. The test is based on the measurement of the increase in optical density $\left(\log \frac{I_0}{I}\right)$ at 340 mμ caused by the reduction of co-enzyme II when reaction 2 proceeds from right to left. The co-enzyme II (I am indebted to Prof. S. Ochoa and to Dr. G. A. LePage for earlier gifts of this substance) was prepared in collaboration with Drs. P. K. Stumpf and F. R. Whatley from pig livers according to the methods of LePage and Mueller[13]. Preliminary tests disclosed that the 'malic' enzyme was present in the cytoplasmic fluid but not in the chloroplast fragments. This conclusion was confirmed when crude 'malic' enzyme preparations were made from these two fractions by the ammonium sulphate fractionation procedure of Vennesland[14]. No active preparation was obtained from the chloroplast fragments. The activity of the 'malic' enzyme obtained from the cytoplasmic fluid is shown in Fig. 1. Finding the 'malic' enzyme in the cytoplasmic fluid provided experimental evidence for the original hypothesis in the sense that at least one carbon dioxide - fixing enzyme system was shown to be localized outside the chloroplasts in the two species tested.

The next step was to link the 'malic' enzyme obtained from the cytoplasmic fluid with the photolysis of water by chloroplast fragments. If oxidized co-enzyme II could serve as the hydrogen acceptor in the photolytic reaction of isolated chloroplasts, then in a bicarbonate-containing medium a manometric test for oxygen evolution could serve as a measure of the photochemical carbon dioxide fixation according to the following reactions:

$$H_2O + \text{co-enzyme II} \xrightarrow[\text{chloroplasts}]{\text{light}} \text{co-enzyme II.}H_2 + \tfrac{1}{2}O_2; \quad (3)$$

$$\text{Pyruvate} + CO_2 + \text{co-enzyme II.}H_2 \xrightarrow{\text{'malic' enzyme}} \text{malate} + \text{co-enzyme II}; \quad (4)$$

$$\text{Sum: Pyruvate} + CO_2 + H_2O \xrightarrow[\text{'malic' enzyme}]{\text{light, chloropl., co-enzyme II}} \text{malate} + \tfrac{1}{2}O_2. \quad (5)$$

Reaction 4 gives no pressure change, since the fixation of carbon dioxide results in the formation of the second carboxyl of malate, which displaces an equivalent of carbon dioxide from bicarbonate. There will be, however, a positive pressure-change in the over-all reaction 5, due to the production of oxygen from reaction 3. Fig. 2 shows oxygen evolution under the influence of light by the complete system consisting of chloroplasts, 'malic' enzyme, co-enzyme II and pyruvate in a bicarbonate buffer. The methods used were those previously described[8], except that the chloroplast fragments were thoroughly washed and re-suspended in glass-distilled water prior to the high-speed centrifugation. The washing and re-suspension procedure was repeated three times. An independent check of the photolytic viability of the chloroplast fragments using quinone as the hydrogen acceptor[8] was included in each determination.

A photochemical enzymatic reaction was thus reconstructed outside the cell, in which the light energy was used for the reductive fixation of carbon dioxide with a concomitant evolution of oxygen. A notable feature of the present system is that the enzymes and cellular fragments used were obtained from green leaves. As for the single exception of co-enzyme II which was from animal sources, it is known that this co-enzyme is also found in leaves[15]. The evaluation of the full significance of this extracellular photosynthetic reaction in the general scheme of photosynthesis *in vivo* must await further work. Although malic acid has been found in short-time photosynthesis with carbon-14 dioxide, recent inhibition experiments suggest that this organic acid is not a precursor of phosphoglycerate, the chief product of short-duration photosynthesis[16].

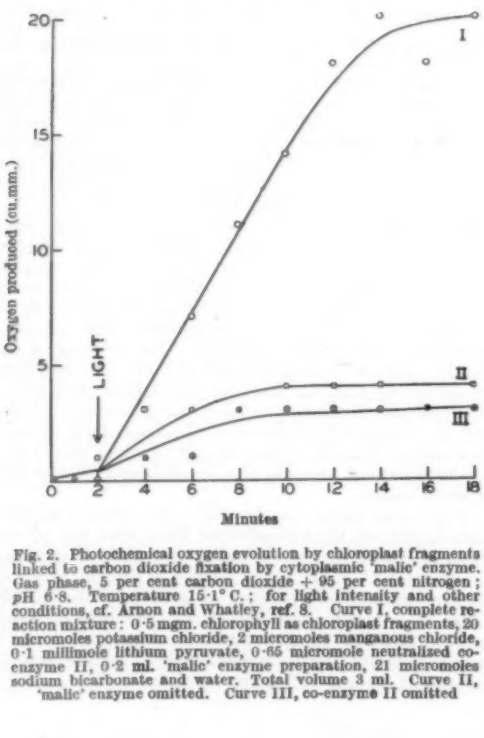

Fig. 2. Photochemical oxygen evolution by chloroplast fragments linked to carbon dioxide fixation by cytoplasmic 'malic' enzyme. Gas phase, 5 per cent carbon dioxide + 95 per cent nitrogen; *p*H 6·8. Temperature 15·1° C.; for light intensity and other conditions, cf. Arnon and Whatley, ref. 8. Curve I, complete reaction mixture: 0·5 mgm. chlorophyll as chloroplast fragments, 20 micromoles potassium chloride, 2 micromoles manganous chloride, 0·1 millimole lithium pyruvate, 0·65 micromole neutralized co-enzyme II, 0·2 ml. 'malic' enzyme preparation, 21 micromoles sodium bicarbonate and water. Total volume 3 ml. Curve II, 'malic' enzyme omitted. Curve III, co-enzyme II omitted

The investigation was supported in part by a grant from the United States Public Health Service.

[March 12.

Note added in proof. Since this communication was prepared, S. Ochoa and W. Vishniac have reported synthesis of malate by 'malic' enzyme of pigeon liver linked through triphosphopyridine nucleotide to illuminated spinach chloroplasts (*Nature*, May 12, p. 768). Similar results have also been obtained with tracer carbon by L. J. Tolmach (*Nature*, June 9, p. 946).

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THE WORLD LAND USE SURVEY

By Prof. L. DUDLEY STAMP, C.B.E.

MANY scientific workers on both sides of the Atlantic must be seriously perturbed by certain aspects of present official policies regarding the so-called 'underdeveloped lands'. The current intense interest of the United States in the problem stems especially from the famous Point 4 of President Truman's address to Congress in January 1949. The precise wording of that declaration is significant: "Fourth, we must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of under-developed areas. More than half the people of the world are living in conditions approaching misery. . . . For the first time in history, humanity possesses the knowledge and the skill to relieve the suffering of these people."

While this is a magnificent declaration of good intention, it is also a very boastful statement. Is it,

in fact, the case that we have the necessary knowledge of the physical and human conditions in tropical Africa or tropical South America, which have come to be regarded as the typical 'underdeveloped lands'? Plans are being formulated as if the statement were true; but in very many directions precise information is very seriously inadequate or even entirely absent. All land planning and development must start, *ipso facto*, from the present position. Surely we should have, as a *sine qua non*, an accurate and detailed survey of the present use or (what is just as important) lack of use of land, and that we should humbly and patiently seek to separate and evaluate the many factors—whether physical factors of relief, drainage, climate, soil, incidence of plant and animal pests and diseases; or historical, social and economic factors such as agricultural organization, land tenure, and population density, and many others—responsible for the present position. The factors which have operated in the past are for the most part still at work to-day and will continue to exert their pressure in the future: we need to know and understand them.

Almost simultaneously the need for such a primary survey or inventory of land use was put before the Pan-American Institute of Geography and History by Prof. Preston James (Syracuse) and others for the Americas, and before the Lisbon Conference (Easter 1949) of the International Geographical Union by Prof. Samuel Van Valkenburg (Worcester, Mass.) for the whole world, especially the underdeveloped lands. Both proposals have borne fruit. The Institute, restricted to the Americas, is working on pilot areas in Brazil, Bolivia and elsewhere. With the financial help of the United Nations Educational, Scientific and Cultural Organization, the International Geographical Union set up a Commission which met at Worcester, Massachusetts, under the chairmanship of Van Valkenburg and drew up a scheme for a 'World Land Use Survey'. The Commission members were Hans Boësch (Zurich), Pierre Gourou (Brussels and French tropics), Leo Waibel (Brazil, now Minneapolis) and L. Dudley Stamp (British Commonwealth). After ten days discussion, when many expert witnesses from different parts of America were cross-questioned, a unanimous report was drawn up. The report, after emphasizing the urgency of the world problems of population and food supply and the inadequacy of present information, pointed out that the collection of statistics could not replace the need for recording the facts on maps. Emphasis was laid on the need for a factual, objective record from which any subjective element should be eliminated. So many surveys introduce categories such as "land which ought to be forested", or land "suitable for irrigation", involving subjective judgments, that their value as factual documents is lost.

The report gives a 'master key' of land-use categories which the members of the Commission regarded as applicable to the whole world, and careful notes are given on each category. They stress that each category can be and should be subdivided according to local needs, but in such a way that the main classification is preserved and correlation thus permitted between one country and another. The main categories are: (1) settlements and associated non-agricultural land; (2) horticulture; (3) tree and other perennial crops; (4) cropland—(*a*) continual and rotation cropping, (*b*) land rotation; (5) improved permanent pasture; (6) unimproved grazing land; (7) woodlands (in six categories); (8) swamps and marshes; (9) unproductive land.

Having in mind the great variety from country to country of available base maps, the report simply advocates that each country should choose the most suitable scale available—having doubtless in mind the 1-inch or equivalent scales where possible—but for uniform publication all over the world the only base map generally available is the 1-million, which was accordingly adopted, with proposals for accompanying explanatory memoirs.

The report indicates the need for a world organization, but makes it clear that such a gigantic scheme is only possible if widely supported by official or unofficial organizations throughout the world.

There is obviously a considerable gap between a report and a practical demonstration, and the Commission realized the need for a number of pilot surveys. Envisaging eventually dual headquarters in the Americas and the Old World, I agreed to undertake the establishment and direction of headquarters for the Old World on a trial basis. The Council of the Royal Geographical Society generously agreed to provide accommodation, and the Director of the Society afforded every facility in his power. Mr. John Callow, from whom particulars are obtainable, was appointed organizing secretary and started his task on January 1, 1951. Dr. G. H. T. Kimble, secretary-treasurer of the International Geographical Union, in his recent tour of Africa, secured many promises of collaboration, with the result that pilot surveys have been started. Areas where work has been initiated include the Gold Coast, Nigeria, Ceylon and Singapore. The Canadian Government has organized pilot surveys. Italy has set up a national committee to carry out the survey there and in Somaliland; India has also established a national committee; work in Switzerland is in progress. Survey parties from British universities are undertaking land-use surveying as part of their programmes in Libya, Kenya and elsewhere.

Headquarters has paid particular attention to the use of material already available. A bibliography of maps and reports has already been compiled. Mr. C. J. Richards, former settlement officer in Burma, has shown that use can be made of the existing maps and detailed settlement reports of the districts by preparing both land use maps and general reports on Tharrawaddy and Katha. Particular attention has been paid to the use of air-photographs, since complete cover now exists for large areas of underdeveloped lands. Through the kindness of Brigadier M. Hotine, director of Colonial Surveys, Mr. Callow has been allowed access to the files of photographs and has constructed a detailed land-use map of a section of Nyasaland on the scale of 1 : 50,000. This is now to be sent for ground checking on the spot; but it suggests that a truly surprising amount of detail can be elicited from the aerial photographs and that it would be possible to prepare land-use maps simultaneously with the base maps now in course of publication throughout the British Colonial territories.

The next stage is for the Survey to become established on a permanent basis. The need is there, the material is there, and personnel is available. The urgent requirement is finance. Some of the maps prepared to date will be available for inspection and discussion at the Edinburgh meeting of the British Association.

GEOPHYSICAL AND METEOROLOGICAL CHANGES IN THE PERIOD JANUARY–APRIL 1949

By Dr. W. J. G. BEYNON and G. M. BROWN
Department of Physics, University College of Swansea

IN the course of some recent studies of geophysical and meteorological data, we have noted that during the period January–April 1949 there appeared to be unusual correspondence between certain solar and terrestrial phenomena. In the present communication we consider the following data: (*a*) the daily noon atmospheric pressure at the ground (measured at Kew, London); (*b*) the deviations from the monthly mean curve of the daily noon values of the vertical-incidence critical frequencies of normal region *E* and region *F*2, denoted by ΔfoE and $\Delta foF2$ respectively (measured at the Radio Research Station, Slough); (*c*) the daily *K*-index of geomagnetic activity (measured at the Abinger Magnetic Station of the Royal Greenwich Observatory). The distances between the three observing stations being only a few kilometres, the data may be taken to refer to measurements made essentially at the same site.

Our attention was first attracted to this period by the sequence of four maxima in atmospheric pressure, at approximately 27-day intervals. This is illustrated by the full-line curve of Fig. 1, which represents five-day moving mean noon pressure measurements at Kew. In the same diagram is shown a corresponding moving mean curve for ΔfoE plotted with its negative axis upwards. The close correspondence between these curves (often in detail) is clear, showing a strong *inverse* correlation between ΔfoE and ground pressure, a change of 10 mb. corresponding to a variation of about 0·1 Mc./s. in *foE*.

An examination of other ionospheric data over the same period shows that these variations in the atmosphere extended to the level of region *F*2. Thus the curve for $\Delta foF2$ (Fig. 2) clearly follows those for ground pressure and ΔfoE. For comparison purposes we have also included in Fig. 2 the variation in the Abinger daily *K*-index of geomagnetic activity. The general correspondence with the other curves is at once evident.

A study of solar and geomagnetic data for this period suggests that these large-scale atmospheric changes can be ascribed to the combined influences of sunspot groups, chromospheric eruptions, and the agents responsible for magnetic and ionospheric storms. The incidence of the more important of these is indicated in the lower parts of Figs. 1 and 2. In considering effects on individual days it is important to remember that the curves are smoothed over periods of five days, with the result that, sometimes, maxima or minima may be displaced slightly with respect to the corresponding turning points in the unsmoothed data. We have verified that smoothing the data in the above manner does not affect the arguments which follow.

Outstanding features of the period under consideration include the occurrence of unusually large spot groups with central meridian passages on January 22.7 and February 5.4 (the respective areas of the groups being 2,400 and 2,200 millionths of the solar hemisphere). The former group persisted for three solar rotations, the subsequent central meridian passages being on February 19.3, March 19.3 and April 16.2. A further group of area exceeding 1,000 millionths crossed the central meridian on February 27.3. The central meridian passage of the group on January 22.7 was followed, some forty hours later, by a 'sudden commencement' great magnetic storm, together with a spectacular auroral display observed in Great Britain. The subsequent central meridian passages of this group in February and March were again followed by smaller 'sudden commencement' magnetic storms (February 21 and March 21). It is perhaps relevant to note that this recurrence feature is not usually associated with great 'sudden commencement' magnetic storms. It is seen from Fig. 1 that further 'sudden commencement' magnetic storms occurred on March 16–17, April 7–8 and April 12–14, and that five ionospheric storms were also recorded. This period was thus one of quite large magnetic and ionospheric disturbance.

In another communication we present evidence for a tendency for a 27-day recurrence in normal *E*-layer critical frequency, which shows a close positive correlation with sunspot numbers, whereas Fig. 1 would appear to suggest a negative correlation between *foE* and the incidence of large sunspot groups. However, we have made a detailed examination of the variation in *foE* and *foF*2 over this period, considering the influences of sunspots, solar flares and magnetic disturbances, and find that the apparent anomaly results entirely from the large

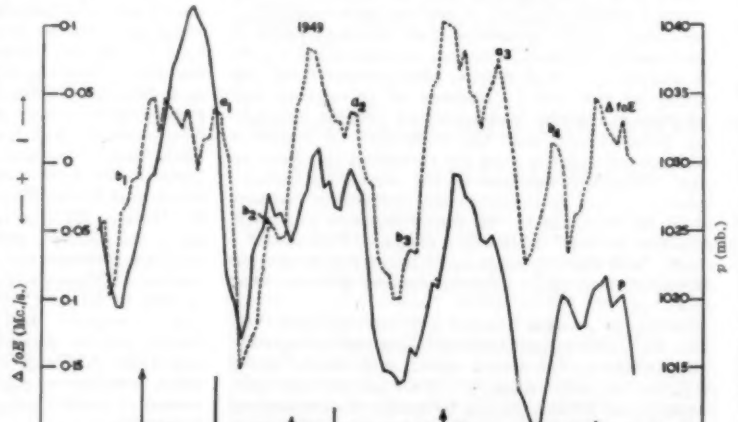

Fig. 1. Five-day moving mean values of ground pressure (———) and ionospheric departure ΔfoE (– – – –). Incidence of sunspots and storms: | central meridian passage of sunspot group (height of line proportional to area of group; vertical lines with arrows indicate successive appearances of the same group); ■ sudden commencement magnetic storm; ● ionospheric storm

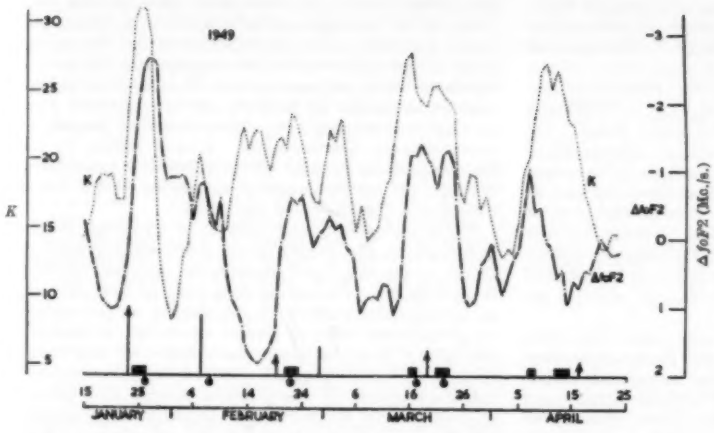

Fig. 2. Five-day moving mean values of ionospheric departure $\Delta foF2$ (— · — ·) and magnetic activity K (.....). Incidence of sunspots and storms: | central meridian passage of sunspot group (height of line proportional to area of group; vertical lines with arrows indicate successive appearances of the same group); ■ sudden commencement magnetic storm; ● ionospheric storm

depressions in E and $F2$ critical frequencies which occur at the time of magnetic and/or ionospheric storms. The subsidiary peak a_1 in the ΔfoE curve (Fig. 1) represents a typical depression in foE at a time of enhanced magnetic activity, as can be seen from inspection of the K-curve (Fig. 2). It is interesting to note that similar subsidiary peaks recur at approximately 27-day intervals (points a_1, a_2 and a_3), when the K index also shows maxima of magnetic activity. Furthermore, we note the 27-day intervals between the points b_1, b_2, b_3 and b_4 on the ΔfoE curve, these again corresponding to maxima in the K-curve. The very pronounced depression in foE represented by point b_4 is no doubt associated with the magnetic storm of April 7–8.

It is a matter of considerable interest to note that many of the subsidiary maxima in the curve of ground pressure appear to correspond with the detailed fluctuations discussed in the preceding paragraph. It would clearly be interesting to have information concerning the behaviour of the atmosphere at some level between the ground and the E region over this period; such may be provided by daily measurements of ozone content, but unfortunately no British ozone measurements were available in the first part of 1949.

In considering the curves of Figs. 1 and 2, it is of interest to recall that many workers have previously presented evidence for relations between one or other of the parameters concerned. Thus the parallelism between magnetic activity and depressions in $F2$-ionization is well established (Appleton and Ingram[1]). A comprehensive study of the relationship between sunspot numbers and atmospheric pressure was published in 1915 by Sir Gilbert Walker[2], in which data from 93 stations were analysed. Walker's analysis indicated that increased solar activity seemed to increase the pressure in areas where it was normally high and decrease it in areas where it was normally low. In 1936, Martyn and Pulley[3], using data for Sydney, Australia, showed that a *positive* correlation sometimes existed between ground pressure and E-layer critical frequency. This, it is to be noted, is in the opposite sense to the results here presented. Furthermore, their results indicated a variation in ΔfoE, for a given pressure change, some three times the magnitude of that found by us. In considering this reversal of sign as between Great Britain and Australia, it is interesting to note that the results of Walker indicated that whereas for most of Europe the correlation between sunspots and pressure was positive, in Australia the correlation appeared to be negative. Stagg[4], in 1931, concluded that, in years of feeble sunspot activity, ground pressure variations at Aberdeen showed significant differences on magnetically quiet and disturbed days, and that in active years such differences were masked or even reversed in sense. For the period under review we have examined the values of foE and ground pressure (p) at noon on the five international magnetic days, and find that there seem to be significant differences between the quiet and disturbed days. Thus, in each of the four months January–April 1949, the mean values of ΔfoE for the five disturbed days are always less than the mean values for the five quiet days. We also find that, with the exception of January, the mean values of Δp (departures of pressure from monthly mean value) on the magnetically disturbed days are slightly larger than those on the quiet days. These results (exhibited in Fig. 3) are consistent with the more general results represented in Figs. 1 and 2 and can be reconciled with the conclusions of Walker, and also with those of Stagg concerning periods of great solar activity. This, of course, is a very small sample of data and refers to an unusual period, and too much significance must not be placed on the Δp curve in Fig. 3.

A survey of meteorological data shows that during the winter of 1948–49 and in particular during the early months of 1949, weather conditions in parts of Europe and North America, and possibly over much larger areas, were in many ways remarkable[5]. Since the large-scale atmospheric oscillations represented by the curves in Fig. 1 may not be unrelated to the cause of these other abnormalities, some brief mention may be made here concerning them. In Britain, the period September 1948–April 1949 was remarkably dry, rainfall being 30–50 per cent below average. In

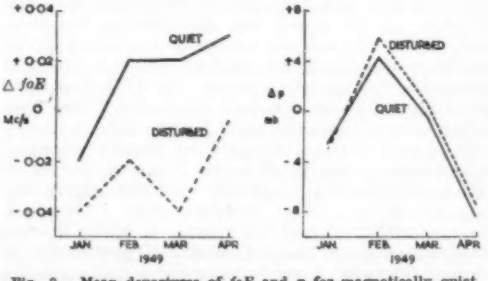

Fig. 3. Mean departures of foE and p for magnetically quiet and disturbed days, January–April 1949

February and March pressure was abnormally high, the average for February being about 10 mb. above normal over most of the country. Exceptional conditions also prevailed in many other parts of the world. In parts of North America the 1948–49 winter was considered the worst in history, that in California being described as the coldest for sixty years. On the other hand, in Ontario the winter was recorded as nearly the mildest on record. In both Britain and Denmark, at least, the year 1949 is given as one of the warmest on record. Against this background of widespread unusual meteorological conditions, the large-scale pressure and ionospheric changes represented in Fig. 1, and which seem to be associated with solar and magnetic disturbance, assume an enhanced interest.

It may be concluded from the present work that quite marked 27-day recurrence tendencies may sometimes occur throughout the terrestrial atmosphere from the ground to the highest levels, and that such tendencies can be associated, directly or indirectly, with the occurrence of large sunspot groups and their accompanying radiations.

This work has been carried out as part of the programme of the Radio Research Board, and this paper is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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THOMAS WRIGHT AND IMMANUEL KANT, PIONEERS IN STELLAR ASTRONOMY*

By Prof. F. A. PANETH, F.R.S.

In a recently published book[1], the Astronomer Royal gives the following overall picture of the universe as revealed by observations with modern large reflecting telescopes:

"Space, out to the present extreme limits of observation, is populated with a vast number of 'island universes'; these universes are more or less uniformly distributed, except for some local clustering here and there; they are flattened disk-like structures, in slow rotation. . . . Within the distance of 500 million light-years, which is the limit of present surveys, there are about 100 million separate island universes."

It is of historical interest that already in the middle of the eighteenth century essentially the same structure of the world was described as the most likely one. The modern theory of rotating galaxies has been developed to account for the observed differential motion of the stars; in 1775 Immanuel Kant predicted this motion because he was convinced that the galaxies must be rotating.

The trend of thought which led Kant to this far-sighted idea is explained in his "General Theory of Celestial Evolution". While the cosmogony expounded therein—often coupled, with little justification, with the name of Laplace—is widely known, it seems to have escaped attention how much of permanent value is contained also in the short "Part I" of the book, where Kant in a dozen or so pages describes what he believes to be the present state of the stellar world, thus preparing the basis on which to build his cosmogony. It is astonishing how near he comes to the modern picture outlined above, leaving far behind the conceptions of earlier and contemporary astronomers. It will suffice to refer for comparison to those of Isaac Newton and Thomas Wright, on whose theories he largely relied for the construction of his own universe.

Notwithstanding the enormous progress Newton had made in the explanation of the solar system, his views about the fixed stars were not very different from Kepler's. The sun and its planets were supposed to occupy the middle of an almost empty sphere; the fixed stars, that is, all the constellations including the Milky Way, were on the surface of this distant sphere. Newton applied celestial mechanics only to the movements of the planets, moons and comets; it was merely to prove the working of a supreme intelligence when he asked the question: "What hinders the fixed stars from falling upon one another?" The implied answer is: God keeps them apart, against the forces of gravity. Newton's interest as a natural philosopher scarcely extended beyond the solar system, the members of which offered so much scope for the application of his law that, even after his death, throughout the eighteenth century, professional astronomers were almost exclusively occupied with this kind of applied mathematics. There is only the one remarkable exception, Thomas Wright of Durham, who in 1750 published "An Original Theory, or New Hypothesis of the Universe", in which book for the first time[2] the idea was advocated that the circular white band of the Milky Way was not one of the constellations on the celestial globe but an indication that the stellar system to which our sun belongs extended much farther in this direction than in others. Wright thus anticipated by thirty-five years Herschel's idea of a disk-like shape of the universe[3].

The question of the dynamic stability of this 'creation' did not worry Thomas Wright. He does not even mention it in his "Original Theory"; but from the drawings added which show every star with its planets and comets contained in a spherical shell, it is obvious that he remained faithful to an opinion expressed by him in an earlier work in the words: "Each star hath a gravitating Power independent of each other", so that "these several Systems cannot interfere with one another".

Kant, in Part I of his cosmogony, makes it clear that it was Thomas Wright's idea of a flat stellar universe which inspired him to think out his own theories; as he never saw Wright's book but only a short abstract, he was not sure "in what details he had merely imitated his sketch or had carried it out further". For us it is easy to see that the main difference is Kant's attempt to explain the origin of our world, while Wright was satisfied with describing its present state; but also Part I of Kant's treatise which, as an introduction, is devoted to the same more restricted task, goes far beyond Wright's original conception by assuming that gravitational attraction is "unlimited and universal". How can it then be that the stars of the flat galaxy do not fall towards the centre? Newton's theological solution could not satisfy Kant; although equally convinced of God's role as a creator, he shared Leibniz's opinion that the world, once in existence,

* Substance of a Friday Evening Discourse delivered at the Royal Institution in London on April 6, 1951.

could continue by itself, and that its beautiful and permanent order was a better argument than interference for God and Providence.

So, more Newtonian than Newton himself, Kant applied to the stellar universe the same principle which had solved the problem of the solar system. The crucial passage, in Kant's own words, is :

"We will try to discover the cause that has made the positions of the fixed stars come to be in relation to a common plane. According to all appearance the force of attraction extends ad infinitum. Thus all the systems of the universe are found so constituted by their mutual approach, which is incessant and is hindered by nothing, that they will fall together sooner or later into one mass, unless this ruin is prevented by the action of the centrifugal forces, as in the globes of our planetary system. The form of the starry heavens is therefore due to no other cause than such a systematic constitution on the great scale as our planetary world has on the small—all the suns constituting a system whose universal relative plane is the Milky Way.

"This new theory attributes to the suns an advancing movement ; yet everybody regards them as unmoved, and as having been fixed from the beginning to their places. But in all probability this want of movement is merely apparent. It is either only excessively slow, arising from the great distance from the common centre around which the stars revolve, or it is due to mere imperceptibility, owing to their distance from the place of observation. Now, as there are perhaps very few fixed stars so near the sun as Huygens has conjectured Sirius to be, as the distance of the rest of the heavenly host perhaps immensely exceeds that of Sirius, and would therefore require incomparably longer time for such a periodic revolution ; and, moreover, as it is very probable that the movement of the suns of the starry heavens goes round a common centre, whose distance is incomparably great, so that the progression of the stars may therefore be exceedingly slow, it may be inferred with probability from this, that all the time that has passed since men began to make observations on the heavens is perhaps not yet sufficient to make perceptible the alteration which has been produced in their positions. We need not, however, give up hope yet of discovering even this alteration, in the course of time."

That, indeed, many of the 'fixed' stars show appreciable movements had been proved beyond doubt by the middle of the nineteenth century ; but the nature of these movements did not become clear until much later. Step by step certain regularities were recognized ; about 1920, Kapteyn's theory of two stellar streams was widely accepted, and sometimes it was stated in so many words that there was no indication of a rotation of the galaxy. It was only in 1926–27 that Lindblad and Oort successfully applied this hypothesis which, thanks to the additional work by J. S. Plaskett, von der Pahlen and Freundlich, Eddington and others, quickly received general approval. In 1931 Jeans wrote : Why do not all the stars of the galaxy "fall together in a bunch at the centre ? This puzzle is now solved". Actually it was solved as early as 1775, by Immanuel Kant.

In still another important respect Kant forestalled the modern conception of the stellar universe : in his interpretation of the nebulæ as external galaxies. A glimpse of this idea is to be found in Thomas Wright's book, where reference is made at the end to :

"the many cloudy Spots, just perceivable by us, in which tho' visibly luminous Spaces, no one Star or particular constituent Body can possibly be distinguished ; those in all likelyhood may be external Creation, bordering upon the known one, too remote for even our Telescopes to reach".

This passage was unknown to Kant, when he expressed the same thought in more precise form and supported by an entirely new argument :

"I come now to that part of my theory which gives it its greatest charm. The train of thought is short and natural ; it consists of the following ideas. If a system of fixed stars which are related in their positions to a common plane, as we have delineated the Milky Way to be, be so far removed from us that the individual stars of which it consists are no longer sensibly distinguishable even by the telescope ; then this world will appear under a small angle as a patch of space whose figure will be circular if its plane is presented directly to the eye, and elliptical if it is seen obliquely.

"We do not need to look long for this phenomenon among the observations of the astronomers. It has been distinctly perceived by different observers. [Here Kant refers particularly to M. de Maupertuis's description of 'nebulous stars'.] All this is in perfect harmony with the view that these elliptical figures are just universes and, so to speak, Milky Ways, like those whose constitution we have just unfolded. And if conjectures, with which analogy and observations perfectly agree in supporting each other, have the same value as formal proofs, then the certainty of these systems must be regarded as established."

The above quotations from Kant are given in W. Hastie's translation[4], with omissions, but without any changes. The translation is very accurate, but exception can be taken to the use of the word 'universe' in the plural. Some years ago Kant was blamed for the introduction of the term 'island universes' as being "both illogical and improper"[5]. Actually, Kant never uses universe in the plural, but speaks of 'worlds' or 'world systems', and Humboldt coined the excellent expression 'world islands' (*Weltinseln*), while in the English literature the less correct term 'island universes' has become quite common.

In rounding off his picture of the universe, Kant continues :

"The theory which we have expounded opens up to us a view into the infinite field of creation, and furnishes an idea of the work of God which is in accordance with the infinity of the great Builder of the universe. If the grandeur of a planetary world in which the earth, as a grain of sand, is scarcely perceived, fills the understanding with wonder ; with what astonishment are we transported when we behold the infinite multitude of worlds and systems which fill the extension of the Milky Way ! But how is this astonishment increased, when we become aware of the fact that all these immense orders of star-worlds again form but one of a number whose termination we do not know, and which perhaps, like the former, is a system inconceivably vast,—and yet again but one member in a new combination of numbers ! There is here no end but an abyss of a real immensity, in presence of which all the capability of human conception sinks exhausted, although it is supported by the aid of the science of number."

Adherents of the theory of a finite universe will be inclined to say that in this respect modern science does not confirm Kant's views. It may, however, be permissible to quote here—somewhat condensed—a passage from a fairly recent text-book on astronomy[6], which shows that a structure of the universe is still conceivable which is very near to Kant's hierarchic order :

"Our super-galaxy is made up of the Milky Way, the globular clusters, and many others of the nearer galaxies. We shall call this a super-galaxy of the first order. Our

own super-galaxy and those in Centaurus, together with an unknown number of others which we have not yet discovered, constitute our super-galaxy of the second order. Beyond the borders of our super-galaxy of the second order there is not limitless unoccupied space. At distances that are enormous in comparison with its diameter there are other super-galaxies of the second order, in a general way similar to our own. These super-galaxies of the second order are not unrelated cosmic masses lying in the vast void of space, but they constitute similarly a super-galaxy of the third order whose diameter may be a million times that of a super-galaxy of the second order. Now the process of ascent is clear. Each cosmic group, however great, is a minute unit in that of the next higher order, and the sequence continues without limit."

Perhaps Kant, and Moulton, are going too far by assuming an infinite number of galaxies. However that may be, the fact that the existence of at least a hundred million disk-like world islands in slow rotation is to-day well established must fill us with admiration for the genius who, correctly interpreting the very few astronomical observations available, believed in such a universe two hundred years ago.

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NEWS and VIEWS

Expulsion of Corpuscular Streams by Solar Flares

A PAPER by F. D. Kahn on the "Expulsion of Corpuscular Streams by Solar Flares" (*Mon. Not. Roy. Astro. Soc.*, **110**, 5; 1950) gives the results of his investigation of the minimum momentum density in a corpuscular stream emitted from a solar flare which is responsible for a terrestrial magnetic storm. It has been suggested by K. O. Kiepenheuer, F. Hoyle and also by Kahn that radiation pressure due to the flare may cause the expulsion of the cloud, but now it seems very doubtful if this is the mechanism of expulsion. Kahn shows that, under certain reasonable assumptions, the rate at which momentum is given to the stream by the flare must exceed 10^3 dynes/sq. cm. to cause a magnetic storm. While Hoyle obtained a much smaller value than this, he assumed that the particles are emitted radially from the sun, rather than radially from the flare, and he neglected the longitudinal expansion of the stream, which Kahn has taken into consideration. Radiation pressure can act on the particles in two ways: in the resonance process the atoms may absorb resonance radiation coming from the flare, and re-emit at random; in the ionizing process the atoms may be ionized by radiation coming from the flare. It is shown that the former is utterly inadequate to explain the cause of the expulsion, and the efficiency of the latter is next investigated. In the ionizing process, pressure is exerted by ionizing radiation in a way similar to that exerted by resonance radiation, but in the former case the ions which are formed have to re-combine with electrons before they can again be acted on by photons. An upper limit to the effectiveness of radiation pressure can be fixed by the rate of combination, and the acceleration of the cloud by the radiation is investigated, leading to the conclusion that the initial density exceeds 4×10^{15} particles/c.c. if a cloud can be expelled. As the density of the solar atmosphere in the vicinity of a flare is very much less than 4×10^{13} particles/c.c., the ionizing process also fails. It seems, therefore, that some entirely different mechanism of expulsion must be found; and, as the required excess pressure near the flare is only of the order 10^3 dynes/sq. cm., such a mechanism should not prove too difficult to find.

Analysis of Blindness in England and Wales

IN Memorandum No. 4 of the Medical Research Council, "The Causes of Blindness in England and Wales" (pp. 42; London: H.M. Stationery Office, 1950; 1*s.* 6*d.* net), Sir Arnold Sorsby discusses the statistics of blindness in England and Wales since the register of the blind was instituted in 1920. In the twenty years up to 1940 the number of people listed on the register rose from 25,840 to 74,418, with 77,390 in 1948. Since 1937 some 6,000–8,000 new cases of blindness have been registered each year. Sir Arnold records his study of the certificates of 19,149 persons accepted as being blind within the meaning of the Blind Persons Act. They were divided into two groups: 17,430 (91 per cent) showed the same cause for blindness of the two eyes, while 1,719 (9 per cent) showed different causes for the two eyes. Within the former group, 77 per cent were more than fifty years of age when they were registered; but the evidence suggests that the causes of blindness operate most strongly in early and later life. Among the totally blind only 10·2 per cent had remediable blindness, and most of these suffered from cataract. The risk of blindness is substantially the same for both sexes. In the group showing different causes for the blindness of the two eyes, 88·6 per cent were more than fifty years of age, 10·4 per cent suffered from remediable blindness, and men were more often affected than women, because many more men were blinded in one eye by injuries. After a discussion of his analysis, Sir Arnold concludes that, even when full allowance is made for continuing decline of blindness caused by infectious disease and for possible elimination of much blindness due to cataract, more than fifty thousand irremediably blind persons will remain blind, and that this estimate may be too low, because the population nowadays is getting older and senile causes of blindness are prominent in any analysis of the blind population. In the school population the rate of blindness has been almost halved in the past quarter of a century, but it is not likely that much further reduction is possible. After discussing the problems ahead of us, Sir Arnold concludes that we need more intensive hospital administration and better hospital facilities. Further, we still need an understanding of congenital and hereditary anomalies of the eye, of its inflammatory diseases, and of myopia, glaucoma, cataract and 'senile' degenerations.

Imperial College of Science and Technology: New Chemical Laboratories

FIVE new chemical laboratories, with accessory accommodation, constructed in the space formerly occupied by the elementary analytical laboratory, were opened at the Imperial College of Science and Technology, London, on June 15 by Lord Falmouth, chairman of the governing body of the College. On

the ground floor is a laboratory designed for the practical instruction of nearly sixty students entering upon the honours course in chemistry; the accessory accommodation comprises a glass workshop, a metal workshop, an instrument room, a room for preparing materials required in practical examinations, and a store from which materials needed in the department of inorganic and physical chemistry are issued. There is also a small lecture theatre and a laboratory reserved for food analysis, together with balance rooms, service rooms and staff rooms. The upper section of the new accommodation is on a floor provided at half the height of the old laboratory. It comprises a laboratory for general inorganic chemistry and advanced analysis, named the Crookes laboratory after the late Sir William Crookes, who entered the Royal College of Chemistry in 1848 and later held the post of assistant to Hofmann. The laboratory for advanced organic chemistry is named after the late Sir Edward Frankland, Hofmann's successor as professor of chemistry from 1865 until 1885, while that for advanced physical chemistry commemorates the many-sided services to the Imperial College of the late Prof. J. C. Philip, who retired from the directorship of the inorganic and physical chemistry laboratories in 1938 but was afterwards recalled to act for a time as deputy rector of the College. In his address, Lord Falmouth referred to the great importance of practical studies in these days of increasingly complex experimental techniques, and spoke appreciatively of the help that an active school of experimental science derives from the work of an enthusiastic and co-operative team of highly skilled technicians.

Vacuum: A New Scientific Quarterly

During the past thirty years the use of high-vacuum techniques and processes has spread from the research laboratory to many branches of science and industry; references to the latest developments, however, are not easily found, for articles relating to vacuum technology are scattered indiscriminately throughout the scientific and technical literature under headings ranging from engineering to pathology. There is a definite need for a specialized journal which deals with the basic techniques, equipment and industrial applications of vacuum technology, and which collects from the various sources, into a convenient form, detailed information about new developments in this field. Messrs. W. Edwards and Co., Ltd., of London, the well-known manufacturers of vacuum equipment, are therefore to be congratulated for their foresight, and for their enterprise, in launching a new quarterly, *Vacuum*, the first journal in the English language to be devoted solely to vacuum research and engineering (1, No. 1, January 1951; pp. 72; 25*s*. a year). Though *Vacuum*, in addition to being published by a private company is also edited by H. L. J. Burgess, a member of the staff of the same firm, it is intended to make it a strictly impartial and authoritative scientific quarterly with contributions from various sources. The first number contains three original contributions, letters to the editor, book reviews, and a self-contained section, consisting of some forty pages, of classified abstracts of articles on subjects connected with vacuum technology. The leading article is by Prof. E. N. da C. Andrade, who reviews the growth and rapid development during recent years of the use of vacuum processes in research and industry. This is followed by a description by Dr. J. C. Harris, of the Chester Beatty Research Institute, of the application of freeze-drying to the preservation of bacteria and viruses. The third original contribution is by L. Holland, of the research laboratories of Messrs. Edwards and Co., who summarizes the various methods and forms of apparatus used for the production by evaporation *in vacuo* of solid thin films and the properties and uses of such films. Special care has been taken in the classified abstract section to ensure that the section is as complete and comprehensive as possible. The abstracts are printed on one side of the paper only and are detachable ready for filing. They are arranged under four main group headings: general science and engineering, vacuum apparatus and auxiliaries, vacuum processing techniques and special subsidiary apparatus. There are also brief summaries of the abstracts in French.

Rehabilitation

The first issue of a new series of the journal of the British Council for Rehabilitation contains an important article by Sir Harold Wiles on the industrial implications of rehabilitation. Sir Harold describes that part of the rehabilitation process which falls between the completion of active surgical or medical treatment for a particular condition, and the point at which a patient has become fit to start with confidence on doing a full day's work in employment without any special conditions or, alternatively, to start on a full-time course of training to learn some vocational skill for a new kind of employment. In other articles Sir Henry Kessler considers recent achievements in rehabilitation, and Dr. Idris Davies the work of rehabilitation and resettlement which is being done with pneumoconiosis patients in South Wales, while Sheridan Russell examines the place for epileptics in industry. The journal also contains a report of a recent conference on cerebral palsy and an account of the Royal Air Force Medical Rehabilitation Unit at Headley Court, Surrey, as well as a summary of the recommendations drawn up by representatives of the Brussels Treaty countries for the rehabilitation of all disabled people. The journal will be published quarterly by the British Council for Rehabilitation, Tavistock House (South), Tavistock Square, London, W.C.1, price 2*s*.

Giant Squid Stranded in Cornwall

An account of a female giant squid which was found in a live condition near Looe in November 1940 has been prepared by Dr. W. J. Rees (*Bull. Brit. Mus., Nat. Hist.*, 1, No. 2, 29; 1950; 4*s*.). The overall length of this specimen (from apex to tip of right tentacle) was 1,860 mm. It is interesting to note that this species is only known from strandings, and all those hitherto found have been females. A plot of the strandings of this species on the coasts of Britain shows that, except for the Looe specimen, all those previously recorded have been from Scotland and the north-east coast of England. Both *Ommastrephes caroli* and the related *O. pteropus* appear to be true oceanic species, and the catch by a trawler of a single specimen of the latter species in 180–200 fathoms off St. Kilda suggests that their true habitat is off the edge of the continental slope. Dr. Rees considers that they occasionally migrate into the North Sea in summer and are later enfeebled by unfavourable conditions during the winter months. It is only by such careful recording of these rarely found animals that one can begin to learn something of their distribution and habitats.

Mathematics during the Festival of Britain

The College of Preceptors is holding in its premises at 2 and 3 Bloomsbury Square, London, W.C.1, an exhibition entitled "The Teacher: In School and Out", telling the story of developments in the teaching profession during the past hundred years. The Mathematical Association is participating in these events and, under the auspices of the London Branch, a "Mathematics Week" is being staged during July 9–13 (with the exception of Wednesday evening). There will be a comprehensive display of material used in mathematical teaching in educational institutions of all kinds, books from the Mathematical Association Library, outstanding numbers of the *Mathematical Gazette*, etc., and part of the Council Chamber will be set out and used as a classroom. Demonstrations and lectures will also be given. Admission is free. Further information may be obtained from Mr. B. J. F. Dorrington, 20 Montague Avenue, Brockley, London, S.E.4.

1851 Exhibition Awards

The Royal Commission for the Exhibition of 1851 has recently announced the following awards for 1951 (tenable for two or three years) for scientific research as shown. *Senior Studentships* (£600–650 *a year*), R. B. Dingle (Cambridge), theoretical physics at Cambridge; Dr. R. M. Goody (Cambridge), atmospheric physics at Cambridge; Dr. E. W. Simon (Oxford), plant physiology and biochemistry at King's College, London; F. G. Smith (Cambridge), radio astronomy at Cambridge. *Overseas Scholarships* (£350–400 *a year*), W. D. Jamieson (Dalhousie), physical chemistry at Cambridge; R. H. Hall (Toronto), organic chemistry at Cambridge; D. C. Weeks (Melbourne), plant physiology at Cambridge; J. R. Cannon (Sydney), organic chemistry at Cambridge; M. Spiro (New Zealand), physical chemistry at Oxford; Dr. H. Rund (Cape Town), mathematics at Oxford; R. O. Colclough (Trinity College, Dublin), physical chemistry at Leeds; K. K. Pandey (Indian Agricultural Research Institute, New Delhi), cytogenetics at the John Innes Horticultural Institution, Bayfordbury; A. Husain (Dacca), nuclear physics at Glasgow.

Lady Tata Memorial Fund: Awards

The following awards for research in blood diseases, with special reference to leukæmia, to be conducted in the places shown during the academic year beginning on October 1, have been made by the Lady Tata Memorial Fund: *Grants for research expenses and/or assistance*, Prof. Jørgen Bichel (Aarhus), Dr. G. Discombe (London), Dr. Astrid Fagraeus and Dr. Bo Thorell (Stockholm), Dr. N. G. Harboe (Copenhagen), Prof. C. Oberling (Paris), Prof. G. Schallock (Mannheim) and Dr. C. C. Ungley (Newcastle upon Tyne); *Part-time personal grant*, Dr. J. B. G. Dausset (Paris); *Scholarships*, Dr. Pascou Atanasiu and Dr. H. P. L. Febvre (Paris). In addition, a special fellowship has been awarded to Dr. A. R. Gopal-Ayengar, chief research cytologist at the Tata Memorial Hospital, Bombay, to enable him to work for a period at the Chester Beatty Research Institute, Royal Cancer Hospital, London.

Summer School on the Physics of Solids

A Summer School on the "Physics of Solids" will be held in the H. H. Wills Physical Laboratory in the University of Bristol during September 6–15. The course, which is similar in conception to those already held on the electrical and mechanical properties of solids, is being arranged by the University and the Institute of Physics. It is intended mainly for research students at universities and for members of the staffs of Government and industrial laboratories who wish to familiarize themselves with the theoretical aspects of subjects with which they are concerned on the experimental side. Lectures will be given by Prof. N. F. Mott, Drs. F. C. Frank, D. Polder and R. Hill and other members of the University. The School will consist of three courses, on electron theory of metals (September 6–8), theory of the mechanical properties of metals (September 10–12), and macroscopic theory of plastic deformations in metals (September 13–15). The last date for application to attend is July 1. Further particulars can be obtained from Mr. W. E. Salt, Director of Adult Education, University, Bristol, 8.

Announcements

Prof. Georges Guillain, professor of neurology in the University of Paris, has been elected a member of the Section of Medicine and Surgery of the Paris Academy of Sciences in succession to the late Prof. H. Vincent.

The following appointments in the University of London have been announced: Dr. Charles E. Dent, to the University readership in medicine tenable at University College Hospital Medical School from October 1; Dr. A. E. F. Moodie, to the University readership in geography tenable at Birkbeck College from October 1.

Instructor Captain W. A. Bishop, director of the Educational Department of the Admiralty since July 1, 1948, has been given the title of director of the Naval Education Service, in view of the wider and greatly increased responsibility of the post since the War, and has been appointed instructor rear-admiral. As well as being head of the Instructor Branch of the Royal Navy, the director of the Education Service is responsible for the educational staffs of the Royal Naval Colleges and Royal Dockyard Schools.

The Second Pan-African Congress on Prehistory will be held in Algiers during September 29–October 4, 1952, with excursions during the fourteen days preceding September 29. Further details can be obtained from the organizing secretary, Prof. L. Balout, Bardo Museum, 3 rue Franklin D. Roosevelt, Algiers.

The annual general meeting of the British Social Biology Council will be held at the Free Church Federal Council, 27 Tavistock Square, London, W.C.1, on July 10, at 2.30, under the chairmanship of Mr. L. J. F. Brimble. After the meeting, Dr. G. C. L. Bertram, director of the Scott Polar Research Institute, Cambridge, will give an address on population trends and world resources entitled "Multiplication for What?" Further information can be obtained from Mrs. French (N.), British Social Biology Council, Tavistock House South, Tavistock Square, London, W.C.1.

In the article "The National Metallurgical Laboratory of India" in *Nature* of February 24, p. 308, it was stated that Prof. Charles Crussard had taken charge of the Laboratory as director. Prof. Crussard has since resigned, and Dr. G. P. (not H. as printed) Contractor, assistant director of planning for the Laboratory, has been appointed acting director.

CEMENT AND CONCRETE ASSOCIATION RESEARCH STATION

OPENING OF THE NEW STRUCTURES LABORATORY

THE opening by the Minister of Works, Mr. George Brown, on May 10, of the recently completed Structures Laboratory of the Cement and Concrete Research Station, Wexham Springs, was an occasion for displaying the whole range of activities of the Station to a large gathering of people representing many sides of industry, science and technology. In introducing the Minister, Sir Francis Meynell, director of the Association, explained that the Cement and Concrete Association was formed in 1935 by the Portland cement industry in the United Kingdom to give technical service to cement users, and the Association obtains its funds from a levy on all cement delivered in Great Britain. Its work includes research, technical advice, publications and training in concrete technology. The new Laboratory is the latest addition to the resources of the Association.

Before opening the Laboratory, Mr. Brown said that he had inspected the Research Station and had been particularly impressed with the work that had been done on the development of surface finishes for concrete. He was glad to know that it is so easily possible to make concrete having an attractive appearance. He regretted that the research programme did not include work on the uniformity of cement and hoped that this might be remedied in the future. He also spoke of the importance he attaches to the proper training of engineers and others engaged in concrete construction and expressed the hope that the training courses run by the Association will be further developed and extended. In thanking the Minister, Mr. A. M. C. Jenour, chairman of the executive committee of the Association, emphasized the degree of co-operation in research that exists between the Association and the various government, academic and professional institutions interested in construction techniques.

The Research and Development Division of the Cement and Concrete Association at Wexham Springs was set up in 1947 in what was formerly a private estate, and is organized into five sections. The Physics and Chemistry Section studies fundamental problems of the behaviour of cement and concrete and is responsible for the development of physical and electrical apparatus required by other sections. The engineering properties of concrete are the main concern of the Concrete and Concrete Materials Section, which pays particular attention to the design of mixes and the problems involved in quality control. The Structures Section studies problems met in designing concrete structures and particularly those new types of structure now being increasingly used in building construction. Certain special problems involved in the use of concrete are dealt with in the Engineering Section, and this Section is at present engaged in work on steam curing and vibration. The Development Section studies works processes with particular emphasis on new methods; its work is directed mainly to the problems of improving the surface appearance of concrete, the development of prestressed concrete roads and of textured surfaces for roads.

A number of outbuildings, originally constructed for more domestic purposes, have been adapted for use as laboratories at the Station; but the Structures Laboratory opened by the Minister of Works is the first of the buildings specially designed for the purposes of research. It is 100 ft. long, 30 ft. wide and 26 ft. high; at one end there is a smaller laboratory, 30 ft. by 30 ft. and 14 ft. 3 in. high, which will be used for making concrete and for research on precast concrete; there are also two small blocks containing offices, stores and lavatories. The main building is constructed with a frame composed of reinforced concrete columns and prestressed concrete main beams supporting the roof; the walls are in brick and concrete block construction with clerestory windows in precast concrete frames. The exterior is finished with a variety of treatments including precast concrete slabs, textured rendering and asbestos cement sheeting.

Special apparatus has been developed for making tests on large structural elements. It was felt that the most economical method of carrying out a wide range of tests of this nature was to construct a universal testing machine capable of being arranged in as many ways as possible. The testing equipment consists essentially of a base plate and an adjustable frame on which hydraulic jacks can be mounted. The base plate is formed by a part of the laboratory floor; it is 40 ft. by 27 ft. in plan and 2 ft. 6 in. thick, reinforced with 1-in. bars at 6-in. centres in both directions at the bottom and 1-in. bars at 21-in. centres at the top. Cast into the floor are 263 screw anchor sockets arranged in an equilateral triangular pattern, and each capable of resisting a pull of 5 tons. Ducts have been provided within the floor, through which prestressing cables may be passed if it is required to be strengthened.

The adjustable frame consists of a system of steel columns and beams in which there have been drilled a number of hole patterns allowing it to be put together in a variety of ways. The frame can be erected to enclose an experimental structure, and with slight adjustments it can be used for direct compression tests on columns or for racking tests on frames. By erecting two separate frames and fixing a cross-member on the experimental specimen to take the thrust of two jacks, torsion tests can be made. It is also possible to make tests on large beams by placing them sideways on the floor and loading them by jacks acting sideways also anchored to the floor.

The jacks are operated by a hydraulic system, fed by an axial plunger pump with a capacity of 938 cu. in. per min. at pressures up to 4,000 lb. per sq. in. driven by a 10 h.p. motor. The straining-rates of the jacks can be adjusted by metering-valves which enable a predetermined amount of the flow to be discharged to exhaust. The equipment has been designed to operate six double-acting jacks, each with an independent pressure-reducing valve. Infinite variation of the force applied by the jack is allowed by the provision of a small back-pressure. The jacks are designed to apply a compressive force of up to 50 tons and a tensile force of up to 21 tons. The line pressure is used for giving an indication of the jack force, but for accurate measurement pressure capsules are inserted between the jack and the specimen.

For convenience of operation, all the controls and gauges have been collected together into one mobile unit. Oil at high pressure is supplied through flexible tubes to the control unit, where it is metered and reduced in pressure and distributed through a further set of flexible tubes to the six jacks inserted between the test frame and the specimen. Although the hydraulic jacks will be used in most experimental work, loads can also be applied by means of dead weights or by air bags acting between the specimen and the reaction framework. For strain measurement on test specimens, it is intended to use electrical resistance methods, acoustic gauges and mechanical dial-gauge strain indicators.

The first work to be undertaken in the new Laboratory will consist of experiments on inter-connected concrete beams prestressed longitudinally and transversely, the aim of which is to compare the performance of the structure in the elastic range with the predictions of theory, and to observe the form of the redistribution of load among the beams after cracking.

The main lines of work of the other sections of the Research Station have already been mentioned; space does not allow these to be fully described, but the following items are of general interest. The Physics and Chemistry Section is working on a semi-micro colorimetric method, using a 'Spekker' absorptiometer, for analysing silicates and other related compounds found in the materials from which concrete is made; this allows the time required for the analysis of cement, for example, to be reduced to one-third or one-quarter of that required when ordinary methods are used.

The section is also engaged on a study of efflorescence on concrete. This phenomenon arises from the leaching out to the surface of lime liberated during the hardening of cement, and little is known of the factors that influence its appearance in any particular circumstances. The work has shown that the physical structure of the concrete and the texture of the surface have considerable effect, and concrete of a wide range of compositions and surface textures is being prepared to determine the conditions in which efflorescence does or does not appear. Apparatus has also been designed for locating and measuring the position of reinforcement in hardened concrete and for measuring the elasticity of concrete by determining the velocity of sound. A study is also being made of surface-active agents used for improving the workability and durability of concrete, while in the future it is hoped to make a fundamental study of the micro-structure of hardened concrete.

In the Concrete and Concrete Materials Section research is being carried out on the quantitative measurement of the shape and surface texture of aggregates by determining the resistance to the flow of a fluid through a bed of the particles, and an attempt is being made to relate the shape and texture with the workability of concrete made from similar aggregates. In the work devoted to aggregates a study is also being made of their absorption characteristics, of the methods of determining their moisture content and of the principles governing the control of moisture content of aggregates on works sites. The Section has completed the collection of data on the mix proportions required to produce concrete of predetermined characteristics with aggregates of $\frac{3}{4}$-in. maximum size, and an examination is now in progress of the factors affecting the design of mixes of very high strength.

The work on steam-curing done by the Engineering Section has made it possible to correlate and reconcile the apparently conflicting results hitherto obtained elsewhere and to gain some insight into the underlying principles involved. A considerable amount of development work is being done on the surface treatment of concrete. This has been concentrated mainly on the use of precast concrete slabs to be used as cladding for buildings or for permanent shuttering, but some work on the surface treatment of *in situ* concrete and external renderings has been done. Emphasis is given to the production of surfaces characteristic of concrete by exposing the aggregate in a number of different ways, and a wide range of coloured and textured finishes has been produced. Tests are being made on the weathering qualities of these slabs both in rural and industrial areas. Investigations are also being made on the production of similar textured surfaces for roads and paved areas, and on the development of prestressing for concrete roads in order to overcome the need for joints and to allow comparatively long lengths of slabs to be laid continuously. It is hoped in this way to save cost and improve the appearance and riding quality. The first experiments on prestressing concrete roads in Great Britain were made at Wexham Springs in 1950 with a simple method of prestressing developed by the staff of the Association.

In co-operation with the Research Committee of the Cast Stone and Cast Concrete Products Industry, work has just begun on a study of problems involved in the compaction of concrete by vibration, in general, and the use of vibration in making precast concrete products, in particular. The work is still in its early stages, but it is planned to test a whole range of commercial vibrating equipment which will also be used to form a permanent exhibition at Wexham Springs.

In 1950 the Association set up a training centre close to the Research Station, and five-day residential courses are held on such subjects as prestressed concrete, design of concrete mixes, quality control of concrete, farm buildings, roads and new developments in technique. Lectures and demonstrations are given, in the main, by members of the research staff; but in some instances outside specialists lecture on their own particular subjects. During the past seventeen months more than five hundred students have attended these courses.

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

THE foundation stone of the last of the series of eleven national laboratories being set up by the Council of Scientific and Industrial Research of India was laid at Roorkee by the Hon. Mr. Sri Prakasa, Minister for Natural Resources and Scientific Research, on February 10. Roorkee has long been well known as an engineering centre. The Thomason Civil Engineering College at Roorkee was a pioneer institution in India, and last year it became the University of Roorkee; now it is accommodating the new Research Institute until such time as the Institute's own building is ready.

Building research was originally conceived as one of the nine divisions of the National Physical Laboratory recently set up at Delhi; but the prevailing

acute housing shortage has heavily underlined the importance of building research, and quite justifiably it has been decided that building research should have a national laboratory to itself, in accordance with the recommendations made by a Building Research Committee at the end of 1943. A Building Research Unit set up in May 1947 is at present working with a skeleton staff in two hangars loaned for the purpose by the University. The Unit has been carrying on useful investigations into soil stabilization and has already obtained important results on the treatment of lime sludges from sugar factories, on cheap houses and on various problems connected with brick-making. It has also published a few brochures on low-cost housing and village housing.

For an institute devoted to building research, Roorkee was the obvious choice. A suitable 10-acre site on its eastern border has been leased by the University of Roorkee to the Council of Scientific and Industrial Research for housing the Institute. The Council has also purchased from the Defence Ministry an S.W.P. hangar (floor space about 3,500 sq. yards), and this is eventually to house the Institute's engineering division and its workshop.

The Board of Scientific and Industrial Research has made provision for a capital expenditure of Rs. 16 lakhs for the Institute, to be spread over a period of three years, and for an annual recurring expenditure of Rs. 4.25 lakhs.

The Institute will undertake research on building materials, on engineering and structural aspects of buildings and their foundations; on problems of comfort in buildings and their durability and the speed of construction. Its activities will naturally include basic research and fundamental studies, such as X-ray investigations and differential thermal analysis of clays and their electro-chemical and rheological properties, strains and stresses in structures and comfort in buildings. It will afford facilities for training men for diverse types of construction and help in the creation of a body of trained men in India.

The functions of the Institute include: (1) examination of building materials in common use and the methods of applying them with the view of economy and improvements; (2) examination of new materials and processes evolved at the Institute and elsewhere; (3) scientific diagnosis of the causes of failures in materials themselves or in their application; (4) dissemination of useful information and fostering the growth of a scientific spirit and outlook in the building industry in India; (5) preparation of standards of materials and codes of practices for various aspects of building construction.

From a slightly different point of view, the subjects of research may be grouped into three main categories: (i) efficiency of buildings, which includes problems like heating, lighting and ventilation; (ii) properties of materials used in buildings, such as cement, plaster, bricks; and (iii) structure and strength of materials.

Dr. J. N. Mukherjee, a distinguished soil chemist, hitherto working with the Indian Council of Agricultural Research, has been appointed director of the new Institute.

Pandit Jawaharlal Nehru, addressing a large gathering on the occasion of the laying of the foundation stone, said that housing is one of the most pressing problems of India. Millions of houses are needed and it would be futile to expect the Government to construct them. "The resources of the Government may be limited, but the resources of the people should never be limited." He disapproved of the attitude of those who looked towards the Government for "parental" help in everything; "the British Government might have acted in this way, but with the achievement of independence people must learn to be self-reliant". Pandit Nehru stressed that manual work must not be looked down upon. He expressed the desire that by the time he visited Roorkee next the students would have constructed some building with their own hands. He added he had seen such things done in the United States and had been impressed by them.

Sir Shanti Swarup Bhatnagar, director of Scientific and Industrial Research, Government of India, said that the eleven national laboratories are only the first stage, and that some further laboratories were already under active consideration. In particular, funds have been provided by industry for a silk and rayon research centre. A national laboratory for electronics and another for atomic energy are also needed.

Laying the foundation stone, the Hon. Mr. Sri Prakasa remarked that in India great attention has been paid in the past to houses for gods, and it is time now to attend to comfortable housing of the common man. Mr. Hart, vice-chancellor of the University of Roorkee, and Dr. Mukherjee, director of the Institute, also gave addresses.

INTERNAL FRICTION OF SOLIDS

THE Physical Society (Acoustics Section), the Institute of Metals and the British Iron and Steel Institute held a combined meeting on March 15 at 4 Grosvenor Gardens, London, W.1, at which ten speakers discussed theoretical and practical aspects of the internal friction of solids.

Prof. A. H. Cottrell (University of Birmingham) opened the proceedings with a survey of generally accepted views on the main causes of internal friction or loss of energy during the vibration of solids. For the sake of brevity he did not discuss friction associated with the magnetostrictive properties of ferromagnetic metals, and for the four main causes he outlined: friction due to the ordering of solute atoms; friction inside single crystals arising from the movements of regions of disarray, that is, of dislocations; thermo-elastic friction due to thermal currents between adjoining crystals; and friction accompanying slip along grain boundaries. The first two occur in both single crystals and in polycrystalline solids, but the other two are restricted to the latter.

The idea of damping due to the ordering of solute atoms was first conceived by Snoek[1], a typical case occurring when the carbon (or nitrogen) atoms which are dissolved interstitially in α-iron, that is, a crystal normally of the body-centred cubic type, diffuse under vibratory stress to positions between pairs of α-iron atoms in the line of stress from positions between orthogonal pairs. For carbon in iron this diffusion process has a time constant τ of about a second at room temperature. This type of contribution to friction has for its main characteristics: a maximum damping for vibrations of angular frequency ω, where $\omega = 1/\tau$, and a variation with frequency according to the usual relaxation law, that is, it varies as $\omega\tau/(1 + \omega^2\tau^2)$; independence of

amplitude; anisotropy, since it varies with the inclination of stress direction to crystallographic axes; and temperature sensitivity with an exponential law corresponding to heat of activation of about 20,000 calories/mol. in the case of carbon in α-iron—this is identical with the activation energy for the diffusion process. Damping investigations in the above category have proved invaluable in providing data on rates of diffusion, equilibrium solubilities and rates of precipitation after quenching or cold working. In the latter case, the mechanism is a little different, involving diffusion to dislocations, a process investigated by Cottrell and Bilby[2] and Harper[3].

Thermo-elastic damping, continued Prof. Cottrell, arises from the heat flow between regions differentially heated by vibratory stress. A time constant $\tau(= x^2/D)$ is involved, where x is the separation of the regions and D is the thermal diffusivity. This type of damping occurs in vibrating reeds and, more commonly, in polycrystalline specimens; on account of the anisotropic nature of the crystals, heat flows across the boundaries in this case. It has the following characteristics: the damping has a maximum for $\omega = 1/\tau$ and follows the usual relaxation law; it is independent of amplitude and insensitive to temperature; and it is dependent on grain diameter x or reed thickness x because these change the time constant τ. Slip along grain boundaries, a creep phenomenon, gives rise to damping and has been thoroughly investigated by Kê[4]. The characteristics of this type of damping are: independence of amplitude; the maximum damping is much larger, half the energy being lost per cycle, than for the other causes discussed above, but this value is substantially independent of frequency, grain size and temperature; and the damping follows broadly a relaxation law with a time constant proportional to $x \exp H/\mathbf{R}T$, H being the heat of activation associated with grain-boundary creep.

The last of the four main causes of friction discussed by Prof. Cottrell was that arising from the movement of regions of disarray, that is, of dislocations inside single crystals. Such behaviour has been investigated by Read[5] and his school in the United States using high frequencies of 10–100 kc./s. It is intimately related to plastic processes going on inside the crystal grains and is extremely sensitive to cold work, the damping increasing from 10^{-5} to 10^{-3} on occasion due to mishandling. The main features of this type of friction are: damping is much reduced by annealing, hydrogen annealing of copper being especially efficacious; damping increases rapidly with strain amplitude; even at low strain amplitudes, metals such as zinc show hysteresis effects but aluminium and copper do not; copper damping is little affected by frequency, but with zinc damping decreases with frequency (Marx and Koehler[6], however, report that copper damping may show a minimum at 20–30 kc./s.); at about room temperatures, Nowick[7] finds an exponential increase in damping with temperature, whereas Bordoni[8] reports maximum damping at about 1/3 Debye temperature on metals.

The next speaker, Dr. J. D. Eshelby (University of Bristol), thought that the problem of damping due to motion of dislocations could conveniently be split into three parts: the detailed mechanism of resistance to motion, dynamics of motion, and means of dissipating energy. For the first, among other possibilities, either dislocations may be regarded as moving in potential wells produced by internal stresses or as being anchored in the neighbourhood of impurity atoms. When a dislocation moves, the stress in its neighbourhood is influenced by the whole previous history of the motion, so that the equation of motion may differ widely from that of a Newtonian particle. Many processes for dissipating energy can be visualized, but their calculation is difficult. One of them, termed 'microthermoelastic' damping, is calculable[9]. A moving dislocation possesses a varying stress field which gives rise to a varying temperature distribution near by and causes damping of Zener's[10] thermo-elastic type, as already described by Prof. Cottrell. Until more is known concerning competing effects, the importance of this mechanism cannot be assessed.

Dr. G. Leibfried (University of Göttingen) first discussed internal friction caused by the motion of dislocations; he thinks the velocity v may be related to the external shear stress X_{ij} through an equation of the form:

$$mv = X_{ij}\lambda - \alpha v,$$

where λ is the distance between nearest neighbours in the lattice, α a frictional constant and m the equivalent mass, the region considered lying between adjacent atomic planes normal to the dislocation line. Making very rough approximations, the value of the frictional constant α arising from thermal sound waves in the lattice can be calculated. The maximum value of the velocity v appears under normal conditions to rise to a tenth of the velocity of sound, and this seems also to hold at zero temperature for zero-point vibrations. Many other causes of loss may, however, be present—for example, radiation damping. Dr. Leibfried pointed out that stress caused by thermal sound waves might be very high, the root-mean-square value attaining perhaps 5 per cent of the shear modulus, so that it may far surpass any external stress which can be applied. It is to be expected that such stresses will greatly affect the behaviour of dislocations; they may enable obstacles to be overcome and so influence the elastic limit.

The work of Nowick[7] was further considered by Dr. F. C. Frank (University of Bristol). The fact that the elastic constant increment due to the motion of dislocations in a copper crystal is found to be ¾–1¼ times the imaginary increment (that is, the damping component), the ratio being invariant with frequency or temperature, appears to rule out relaxation phenomena as the root cause, but a hysteresis phenomenon could be responsible. Dr. Frank discussed possible sources of hysteresis in dislocation movement, including a novel one stemming from the Frank–Read theory[11] of dislocation ring movement. He has calculated that such a ring, formed of a series of edge and screw dislocations joined by 'jogs', could expand even with strains of the order of 10^{-4}, for it appears that the energy required for movement with production of a vacancy (that is, about 1 eV.) or of an interstitial atom (that is, about 2 or 3 eV.) would be attained.

F. R. N. Nabarro (University of Birmingham) said that he has considered a number of mechanisms which will resist the motion of dislocations, in order to determine the applied stress under which the terminal velocity of a dislocation will reach about 70 per cent of the speed of sound. Above this stress the original avalanche processes of Frank can occur. It seems certain that this critical stress is greater than the stress applied to a single crystal in a creep test, but it may be less than the stresses applied to poly-

crystals during rapid deformation. The most important mechanisms of damping are those proposed by Leibfried[12], and the radiation of sound waves caused by the periodical changes in the form of the dislocation as it moves through the lattice. Leibfried's original estimate of the damping caused by the scattering of thermal vibrations involves a confusion of two mechanisms of scattering, one applicable to any imperfection of the lattice and one peculiar to dislocations. The resulting estimate is certainly too high, but this effect is obviously important.

Speaking about work done at the Royal Aircraft Establishment, Farnborough, by S. Pearson, G. B. Greenough and himself, A. D. N. Smith criticized Kê's theory[13] that the high-temperature 'background' internal friction of annealed metals is due to the presence of dislocations. Experiments show that single-crystal specimens have a greatly reduced background compared with small-grained specimens, and it seems more reasonable to suppose that the difference is due to grain-boundary behaviour rather than that dislocations give rise to very much higher damping when situated in polycrystalline metals than when situated in single crystals. The mechanism proposed by Mr. Smith and his colleagues is that creep occurs at the regions of stress concentration arising from stress relaxation along the grain boundaries at high temperatures. Kê's objection that the stress will be insufficient to cause slip is invalid, since an activated creep may occur at any stress. Experimental evidence of this relation of 'background' to creep is that, at high temperatures, and under minute stresses, wires with high 'background' creep both in torsion and stretching. Single crystals show no such creep.

Dr. K. M. Entwistle said that at the University of Manchester methods of measuring damping have been developed for very low-loss materials such as aluminium-rich alloys, so as to investigate damping during quench ageing from about 20° C. to elevated temperatures. Pains have been taken to reduce the equipment loss to well below the energy-loss figure of 2×10^{-5} per cycle, characteristic of these materials around 20° C. In connexion with Zener's proposed mechanism for damping arising from stress-induced rotation of pairs of solute atoms in certain face-centred cubic solid solutions, Dr. Entwistle thought it likely that, assuming initially random distribution of solute atoms in an as-quenched alloy (for example, aluminium–4 per cent copper), subsequent diffusion might permit localized concentration of copper so that the number of effective atom pairs would rise to a maximum and then decay. By investigating damping in these circumstances, since this will vary similarly, it is hoped to confirm this hypothesis.

At the British Iron and Steel Research Association, said E. Linacre, methods of measuring damping capacity are being developed as a tool for metallurgical research; in particular, grain boundary damping in isothermal transformations, since nucleation and grain growth both occur there in a non-martensitic phase change. The preliminary results on two different steels appear to show considerable damping capacity changes on transformation. Mr. Linacre deprecated the indiscriminate use of logarithmic decrement, Q^{-1}, tan δ and specific damping capacity to specify damping and advocated the use of the first.

K. J. Marsh reported on an investigation of damping in copper and certain tin bronzes which has been carried out at the British Non-Ferrous Metals Research Association using the Kê technique at 0·3–2 c./s. over a temperature range. On 'oxygen free, high conductivity' copper the results agree with Kê's results. Markedly different damping/temperature curves have been obtained for tin bronzes with 3, 6 and 9 per cent tin, but they differ little from each other and do not reflect differences found in their hot-working properties. The damping increases with amplitude for these alloys.

Finally, G. Bradfield referred to Nowick's work[7], pointing out that a dislocation has the qualities of a vector associated with a plane, that is, a uniform distribution of the same kind of dislocation has the nature of a six-rank tensor which is similar to an elastic constant. Such a distribution can alter the six-rank elastic-constant matrix, adding real and imaginary increments for sinusoidal stress conditions. In general, the symmetry will be reduced. The changes in velocity and the attenuation of waves due to the dislocation system will exhibit markedly anisotropic characteristics. Mr. Bradfield traced an interesting parallel between the frequency invariance and dependence on density of dislocations of damping due to the latter and the corresponding damping phenomena for foreign particles suspended in a liquid (see Urick[14]). He felt that it is not yet clear whether a dislocation represents a singularity in mass or elasticity or both. Reporting on work at the National Physical Laboratory, Mr. Bradfield said that, in addition to investigation of elastic constants of alloys, the Read technique is being extended to use quartz resonators for damping measurements up to 400 kc./s. An inductor system has been devised to determine damping on small disks weighing only 1 gm.

G. BRADFIELD

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"WHITE CORRIDORS"

HERE is a new film (produced by Vic Films and to be distributed by G.F.D.), commercially presented as having full "entertainment value" (running for 102 min.), which can be strongly recommended to men of science, medical men and educationists. It is now being exhibited at the Leicester Square Cinema, London, and will eventually be generally distributed.

The film is adapted from the novel "Yeoman's Hospital", by Helen Ashton, and the screen play is written by Jan Read and Pat Jackson. Though not a 'documentary' film, it portrays the running of a present-day general hospital. Here are depicted the workaday lives of resident surgeons and physicians, nurses and patients.

The professional medical man is not likely to find any fault with the method of presentation. The

scenery is typical of a general country hospital; in fact, though we like the title "White Corridors", the original one, "Yeoman's Hospital", seems more apt. There are no luxurious wards with wide passages between them, neither are the theatre nor apparatus extravagantly equipped or designed; the portrayal is faithful.

Though we cannot claim authority to criticize the artistes as such, we were favourably impressed by all of them—doctors, nurses and patients. We would, however, direct especial attention to Miss Googie Withers, who plays the part of a woman house surgeon, and to Mr. James Donald, portraying a young resident especially interested in chemotherapy and physiotherapy. Miss Withers acts with detachment and sincerity; Mr. Donald is the true man of science, enthusiastic though balanced, guarded and logical in his researches. The actions of these two brilliant artistes showed beyond doubt that the authors (Jan Read and Pat Jackson) and the producers (Joseph Janni and John Croydon) took very seriously to heart the necessity for truth and faithful registration. Also, we have little doubt that they went to considerable trouble in consulting medical and scientific literature, institutions and workers. This is revealed especially in the shots of the research laboratory where Mr. Donald (as the research-active resident) is trying to obtain a drug which can effectively tackle penicillin-resistant organisms. His use of the Geiger counter and radioactive cobalt, his handling of the Petri dishes containing growing germ colonies and the shots of these instruments and activities being demonstrated by this research worker to members of the visiting hospital committee (who have to decide whether the limited funds at their disposal shall be devoted to extending his laboratory or to building a nurses' recreation room) could be taking place in any reasonably large hospital fortunate enough to have such an enthusiast on its staff. This is the main reason why we would urge medical and scientific men and women to see the film. Medical practice and scientific research, through the media of good playwrights and a splendid cast of actors, are demonstrated to the public in a manner that is not only interesting and entertaining, but also accurate and true. Not once did we spot any, even possibly excusable, hyperbolical action or word in order to drive home a point.

Even the failings of some doctors and nurses are not ignored. The portrayals of these are well acted by Mr. Jack Watling as a philandering young house-surgeon who has yet to appreciate the true moral status of his calling, Miss Moira Lister as an attractive woman whose profession as a nurse cannot be allowed to govern or even modify her emotional life, and Miss Petula Clark who, with all the determination at her command, will never become an efficient nurse. (Though we were not told, we suspect that the second nurse married one of her patients, which would be for the good of all.)

Medical practice and ethics are continuously illustrated in two distinct ways throughout the film. Miss Googie Withers as the young house surgeon unobtrusively by her very acting (possibly under the guidance of a medical man or woman) shows how a doctor is expected to behave professionally. Always good, at times this actress is even magnificent, so that the audience learns much about medical ethics and practice at the same time as they are enjoying to the full the play of this accomplished actress. On the other hand, Sir Godfrey Tearle, the senior surgeon, brings home to his recalcitrant son (Mr. Watling, the house surgeon) and other members of the hospital staff what are the aims, and even limitations, of medical practice, by means of well-written and well-spoken dialogue.

The film will do much towards giving the public a true picture of some aspects of present-day medical practice and scientific research. Points which emerge include such as the beneficent utilization of radioactive elements, the physiological actions of drugs on germs, the fact that penicillin must not be looked upon as a 'cure-all', the strict discipline which medical men and women must impose upon themselves, the safeguarding of human life by medical ethics as well as medical practice, the academic and professional limitations of the doctor, the need for civic and government authorities to appreciate what research involves both in implication and application, etc. Yet withal, this film is never dull: the plot is interesting, the story well balanced and well told and one's interest continuously maintained. The result is a tribute to medical and scientific research and medical and nursing practice for which all who worked in the making of this film are to be thanked.

CAMBRIDGE UNIVERSITY EDUCATIONAL FILM COUNCIL

THE fourth annual report of the Cambridge University Educational Film Council describes cinematograph activities in the University and problems revealed during 1950. As elsewhere, much more use is made of films in teaching science than art subjects, although the sessions of films for students of economics that were begun as an experiment three years ago continue. Sessions of Russian dialogue and German dialogue films have both been repeated during the past year, while some exploration of the use of films in the teaching of architecture has been undertaken; fortnightly film sessions for students of geography have been inaugurated. The greatest use of films in teaching, however, has been in the Departments of Zoology and Engineering, where films have been made and used in teaching.

Although there are considerable difficulties attending the use of films in research, cinematography is being used for investigations into the flow of gases in internal combustion engines in the Department of Engineering; in connexion with research on survival at sea, in arctic, temperate and tropical waters, by the Department of Experimental Medicine; for laboratory investigation of the action of waves on beaches, by the Department of Geography; and for testing vigilance and for various experiments in the Department of Experimental Psychology.

Among the difficulties which limit film-making at Cambridge are the shortage of facilities and accommodation. There is not at Cambridge a photographic department such as exists at the University of Durham, or a visual-aids centre such as that at the University of Melbourne. There is no institution to provide cinematograph services and to produce films, in the same way that a university press provides printing services and produces books. A particular requirement of Cambridge film-makers is a properly equipped cutting room, and means by which films might be processed within the University are also required.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Masses of Krypton-82, -84 and -86 and Xenon-129 and -132

In the course of our atomic mass measurement programme, we have recently had occasion to measure the masses of some of the isotopes of krypton and xenon by the mass-spectrographic doublet method. These measurements are briefly described below.

Krypton and xenon ions were obtained from a Nier-type of ion source[1] in which gas molecules are ionized by electron bombardment. The ionizing electrons were given energies of about 250 eV. This resulted in a copious production of the doubly-charged krypton and triply-charged xenon ions which were needed for the mass comparisons.

To obtain the mass of xenon-129, the triplet at mass number 43 consisting of singly-charged C_3OH_3 and C_3H_7 and triply-charged ^{129}Xe was photographed. The mass of xenon-132 was obtained from the triplet at mass number 44 consisting of singly-charged CO_2 and C_3OH_4 and triply-charged ^{132}Xe. The following packing fraction differences ($\times 10^4$) were obtained: $C_3OH_3 - {}^{129}Xe$, $\partial f = 11{\cdot}678 \pm 0{\cdot}03$; $C_3H_7 - {}^{129}Xe$, $\partial f = 20{\cdot}152 \pm 0{\cdot}03$; $C_3OH_4 - {}^{132}Xe$, $\partial f = 13{\cdot}083 \pm 0{\cdot}03$; and $CO_2 - {}^{132}Xe$, $\partial f = 4{\cdot}906 \pm 0{\cdot}02$. Assuming the masses of ^1H and ^{12}C to be $1{\cdot}008144 \pm 0{\cdot}000008$ and $12{\cdot}003798 \pm 0{\cdot}000025$, respectively, the packing fraction of xenon-129 is computed to be $-4{\cdot}230 \pm 0{\cdot}03$ from the $C_3OH_3 - {}^{129}Xe$ comparison, and $-4{\cdot}245 \pm 0{\cdot}04$ from the $C_3H_7 - {}^{129}Xe$ comparison. Similarly, two values for the packing fraction of xenon-132 are found: these are $-3{\cdot}953 \pm 0{\cdot}03$ from the $C_3OH_4 - {}^{132}Xe$ doublet, and $-4{\cdot}043 \pm 0{\cdot}03$ from the $CO_2 - {}^{132}Xe$ doublet. The errors which are assigned are probable errors based on the internal consistency of the measured values.

The masses of krypton-82 and -84 were obtained from doublets at mass numbers 41 and 42, the former consisting of singly-charged C_3H_5 and doubly-charged ^{82}Kr, and the latter consisting of singly-charged C_3H_6 and doubly-charged ^{84}Kr. The mass of krypton-86 was computed from the triplet at mass number 43, consisting of singly-charged C_3OH_3, doubly-charged ^{86}Kr and triply-charged ^{129}Xe. The following packing fraction differences ($\times 10^4$) were found: $C_3H_5 - {}^{82}Kr$, $\partial f = 20{\cdot}219 \pm 0{\cdot}03$; $C_3H_6 - {}^{84}Kr$, $\partial f = 21{\cdot}668 \pm 0{\cdot}03$; $C_3OH_3 - {}^{86}Kr$, $\partial f = 14{\cdot}805 \pm 0{\cdot}035$; and $^{129}Xe - {}^{86}Kr$, $\partial f = 3{\cdot}156 \pm 0{\cdot}03$. From these data the packing fraction of krypton-82 is computed to be $-7{\cdot}508 \pm 0{\cdot}035$, that of krypton-84 to be $-7{\cdot}321 \pm 0{\cdot}035$; and the two values for the packing fraction of krypton-86 are $-7{\cdot}357 \pm 0{\cdot}04$ from the $C_3OH_3 - {}^{86}Kr$ comparison, and $-7{\cdot}392 \pm 0{\cdot}04$ from the $^{129}Xe - {}^{86}Kr$ comparison, using as the packing fraction of xenon-129 the value found above.

Since three of these doublets were studied by Aston[2] in 1937, it is thought that readers of *Nature* may be interested in the comparisons shown in Table 1, in which Aston's values for these doublet separations are tabulated together with our values for the corresponding doublets. The two sets of values are seen to be in excellent agreement, a fact which probably should be regarded as a substantiation of both. We are aware of the conservative errors assigned by Aston to his measurements, and it may be that the smaller errors associated with the present measurements are more an indication of optimism than of increased precision. Regardless of the relative accuracies, it is a pleasure to see the pioneer work of Aston standing so well the test of time. It will be recalled in this connexion that Aston's value[3] for the mass of sulphur-32, although under a shadow for some years, has recently been shown[4-7] to be correct.

Table 1. Comparison between Present Values and Those of Aston (1937)

Doublet	Packing fraction difference $\times 10^4$	
	Aston	Present work
C_3H_5–^{82}Kr	$20{\cdot}20 \pm 0{\cdot}15$	$20{\cdot}219 \pm 0{\cdot}03$
C_3H_6–^{84}Kr	$21{\cdot}73 \pm 0{\cdot}15$	$21{\cdot}668 \pm 0{\cdot}03$
C_3H_7–^{129}Xe	$20{\cdot}16 \pm 0{\cdot}1$	$20{\cdot}152 \pm 0{\cdot}03$

The new mass values resulting from the work described in this communication are shown in Table 2. Their relation to other current mass measurements will be discussed in the *Reviews of Modern Physics* in an article now in preparation by one of us (H. E. D.).

Table 2. List of New Mass Values

Nuclide	Packing fraction $\times 10^4$	Mass
^{82}Kr	$-7{\cdot}51 \pm 0{\cdot}04$	$81{\cdot}93843 \pm 0{\cdot}00029$
^{84}Kr	$-7{\cdot}32 \pm 0{\cdot}04$	$83{\cdot}93850 \pm 0{\cdot}00029$
^{86}Kr	$-7{\cdot}37 \pm 0{\cdot}03$	$85{\cdot}93658 \pm 0{\cdot}00024$
^{129}Xe	$-4{\cdot}236 \pm 0{\cdot}02$	$128{\cdot}94536 \pm 0{\cdot}00026$
^{132}Xe	$-4{\cdot}00 \pm 0{\cdot}05$	$131{\cdot}94727 \pm 0{\cdot}00060$

The present experiments have been done with a large Dempster-type double-focusing mass spectrograph[8]. The work has been supported by the United States Atomic Energy Commission.

Cort L. Kegley
Henry E. Duckworth

Scott Laboratory of Physics,
Wesleyan University,
Middletown, Connecticut.
May 2.

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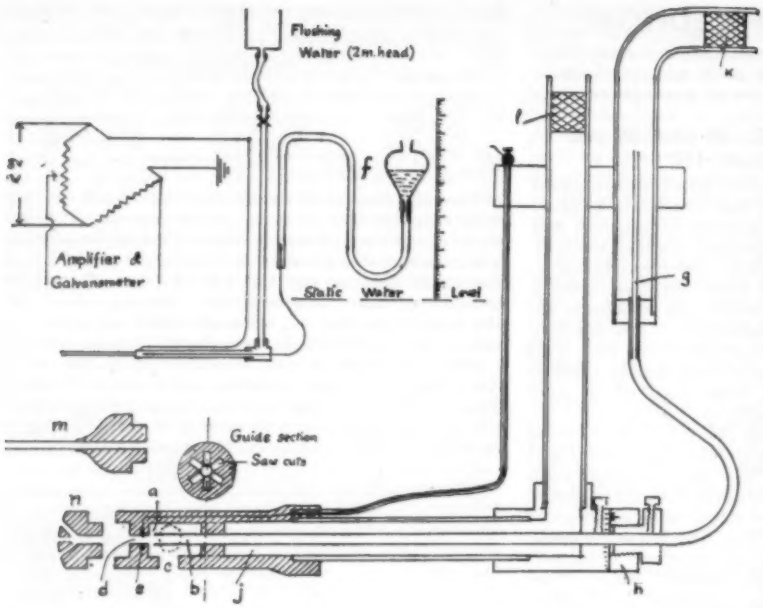
Measurement of Very Low Velocities of Water-flow

The need has been felt for some years past for an instrument which will measure low velocities of water-flow over the cross-section of an open channel or a pipe. The use of the Pitot tube, which has proved so valuable in the case of the flow of gases, becomes quite impracticable in the case of slow-moving liquids owing to the difficulty of measuring the extremely small pressure differences involved and also to the need for strict thermal control of the connecting tubes. Rotating-vane flow-meters are likewise impracticable at low flow values, because of uncertain spindle friction. Exposed hot wires accumulate gas bubbles around themselves, and the enclosed type becomes excessively slow in response as the velocity is decreased.

This same instrumental need is specially acute when research is attempted into the laws governing the transport of solid grains by water. Here the require-



ments have seemed impossibly exacting. For the instrument must: (i) present an aspect area to the flow not greatly exceeding that of a grain, so as not to disturb grain movement; (ii) be independent of direct visual or photographic observation, for the dispersed grains make the fluid opaque; (iii) be independent of any physical property of the liquid itself other than density, since such properties will vary in an unknown way with the presence of the dispersed grains; (iv) be independent of the state of internal turbulence of the flow; (v) give a reasonably quick response; and (vi) respond to flow velocities down to 0·5 cm./sec. corresponding to a velocity head of the order of 10^{-4} cm. of water.

I have recently devised a simple method which by good luck seems to meet all the above requirements. In principle, an opposing counter-flow of controlled velocity of an electrolyte having the same density as the water is made to emerge through a small orifice facing up-stream. This counter-flow is increased until its velocity-head at a fixed distance outside the orifice just balances that of the oncoming flow to be measured. The balance is indicated electrically. By enclosing the meeting-place of the two flows in a small enough space, all purely local turbulence can be inhibited.

The accompanying diagram, in which the diametral scale of all tubes is exaggerated five-fold, shows the present design of the essential instrument head, the machined parts of which are made of 'Perspex'. Numerous possible modifications will, however, at once occur to the reader. Inset is shown the general schematic layout. The electrolyte—dilute ammonia and a metallic salt in proportions adjusted to give equality of density with that of the water—is quite free, on issuing from the mouth of the stainless steel hypodermic tube *a* (0·6 mm. bore), to flow away through the clearance *b* and the holes *c* in the 'Perspex' sheath. But its momentum creates a dome of electrolyte in front of the tube mouth. Hence, depending on the relative intensities of the two flows, the electrolyte either does, or does not, enter the rear end of the hole *d* (0·5 mm. bore), the front end of which is open to the flow to be measured. A platinum or stainless steel electrode ring *e* is sealed into the wall of *d*. A few volts A.C. is applied to this electrode through a bridge-amplifier and galvanometer. The velocity of the issuing counter-flow is controlled by varying the height of the electrolyte surface in the glass reservoir *f* above the static level of the water, and by the viscous resistance of the choke *g*, which consists of a selected length of the finest hypodermic tube (0·25 mm. bore). By increasing the length of this choke tube the hydraulic amplification can be raised to any required value. The present instrument has an amplification of about 10^6. A fine screw adjustment *h* controls the clearance *b*, which should be about a quarter of the bore diameter of *a*. Air bubbles are difficult to dislodge from the tiny enclosed space, so provision is made for injecting, whenever needed, a strong flush of water through the annular space *j* between *a* and the outer 'Perspex' sheath. Small filters *k* and *l* are provided in the supply lines of both electrolyte and flushing water.

Velocity measurement is taken by raising the reservoir *f* until the galvanometer indicates the beginning of a sudden drop in the electrode resistance. Full-strength electrolyte need never be allowed to reach the electrode, and polarization troubles can thus be avoided. Calibration is done by placing over the final orifice the mouth of a converging nozzle through which a metered flow of water is supplied from an external source.

Flow velocities as low as 0·2 cm./sec. can be measured without difficulty. This is equivalent to a pressure difference of only 2×10^{-5} cm. of water. It may be possible to go considerably lower. At slightly higher velocities, repeated readings are consistent to $\pm$ 1 per cent. When the hole *d* is short—two or three diameters only—measurements of these very low velocities can be made in less than 20 sec. But the instrument is very sensitive to fluctuations due to large-scale turbulence in the main flow at higher velocities. Under these conditions, a long thin extension nose *m* is inserted as a viscous choke. Similarly, in the presence of solid grains a short filter-nose *n* is substituted. This has a semi-circular tip which is perforated by six very small holes arranged symmetrically. Since the shape of the tip imitates the exposed surface of a grain, and since, the flow through the nose being zero at the moment of measurement, the blockage of one or more holes has no effect, the instrument can be actually buried below the surface of a sand bed. It then measures the rate of water seepage through the sand. This opens up the interesting possibility of adapting the

instrument to the direct measurement of flow through water-bearing beds *in situ*, at any rate in the case of reasonably permeable sands.

Chemically pure water can, of course, be used in place of electrolyte for the velocity measurement of electrically conducting liquids. The principle should be equally applicable to the measurement of any very small liquid pressure, whether dynamic or static, and therefore, indirectly, to that of pressure differences in ordinary pitot tubes exposed to the very slow flow of gases.

The instrument has been evolved in Prof. C. M. White's hydraulic laboratory at the Imperial College, London, on behalf of the director of the Hydraulics Research Organization, Department of Scientific and Industrial Research, to whom I am indebted for permission to publish this communication.

R. A. Bagnold

Department of Civil Engineering,
Imperial College of Science and Technology,
London, S.W.7.
April 14.

Angular Distributions of Protons from the Reaction $^{13}C(d,p)^{14}C$

Recent studies[1,2] of the angular distributions of protons from (d,p) reactions, produced by bombardment with 8-MeV. deuterons, have revealed very pronounced structures in the distributions, particularly at small angles. To account for these structures, one would have to assume contributions from angular momenta of the incident deuterons much higher than would be compatible with an ordinary reaction proceeding via a compound nucleus. Butler[3] has shown that this difficulty could be removed by the assumption of a stripping process of the deuteron, in which the neutron is captured by the nucleus and the proton moves on with the balance of energy and momentum. This explanation not only accounts well for the observed structure in the angular distributions, but also makes possible the calculation from these distributions of the spins and parities of corresponding states of the residual nuclei. Such a possibility adds great interest to the study of angular distributions in reactions produced by deuterons of sufficiently high energy; the present communication deals with such a study in the case of the $^{13}C(d,p)^{14}C$ reaction.

The 8-MeV. deuteron beam from the Liverpool cyclotron was used for bombarding a gaseous target of acetylene at 10 cm. pressure. The charged particles resulting from the disintegrations were recorded in a photographic plate. The details of the technique and of the experimental arrangement, and the method of determining the differential cross-sections, have been described by Rotblat *et al.*[4] and Burrows *et al.*[5]. It is worth while pointing out that the photographic technique is admirably suited for this type of investigation, since one exposure provides material for intensity measurements over a continuous range of angles. In order not to overlook an important detail in the distribution, which may occur over a narrow range of angles, it is essential to carry out such measurements at a large number of angles.

The examination of the plates revealed numerous groups of protons corresponding to the formation of carbon-13 in various states of excitation. So far, the angular distributions have been studied in detail for the longest two groups of protons, corresponding to

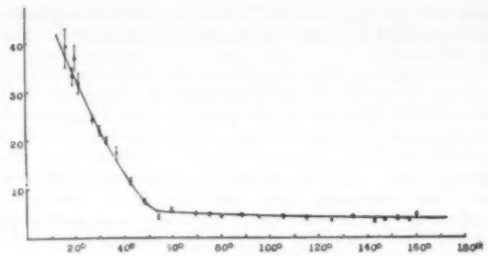


Fig. 1

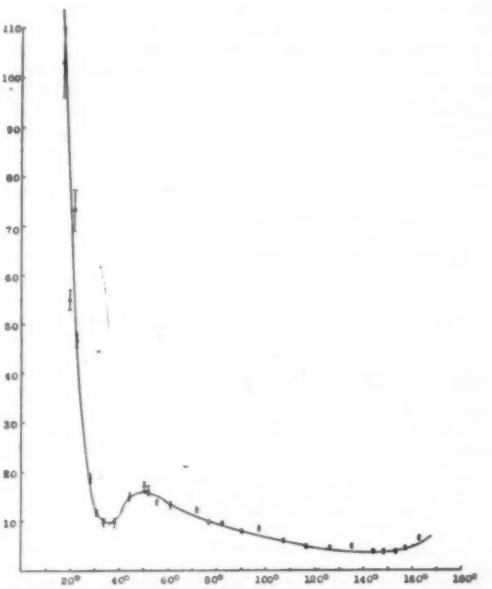


Fig. 2

$^{13}C(d,p)^{14}C$ angular distributions in the centre of mass system. The abscissæ are angles and the ordinates are differential cross-sections in millibarns. Fig. 1 is for the formation of carbon-13 in the ground-state and Fig. 2 for the 3·11-MeV. excited state

the ground-state and first excited state of carbon-13. The Q-values for these reactions are 2·729 and −0·370 MeV. respectively[6]. The numbers of protons in each group, found in a given area, were determined for twenty-seven angles from 15° to 160° in the laboratory system. From the length of the exposure, gas pressure and the geometry of the apparatus, the cross-section per unit solid angle at each angle of observation was calculated. The results are shown in Figs. 1 and 2, where the ordinates are the differential cross-sections (in millibarns) in the centre of mass system, and the abscissæ the angles in the centre of mass system. The vertical lines indicate the probable statistical errors.

It is clear that the two distributions are markedly different. The protons corresponding to the formation of carbon-13 in the ground-state (Fig. 1) show a smooth and gradual falling-off of the intensity from 15° to 55°; at larger angles the cross-section is practically constant. In the case of the protons from the 3·11-MeV. state of carbon-13 (Fig. 2) the cross-section is initially much higher than for the ground-state; it falls very sharply to a minimum at 35°,

rises to a maximum at 50° and then decreases gradually to about the same value, 4 millibarns, as for the ground-state.

A comparison with the curves calculated by Butler[7], for the energies of the bombarding deuterons and the emitted protons, shows that very good agreement is obtained if we assume an angular momentum of 1 for the neutrons captured to form carbon-13 in the ground-state, and an angular momentum zero for neutrons captured into the 3·11-MeV. state of carbon-13. Since carbon-12 has spin zero and even parity, it follows that the ground-state of carbon-13 must have spin $\frac{1}{2}$ or $3/2$ and odd parity, and the 3·11-MeV. state spin $\frac{1}{2}$ and even parity. The spin of carbon-13 in the ground-state is known to be $\frac{1}{2}$ from direct observations (Jenkins[8]).

The present assignment of spins and parities to the two states of carbon-13 fits in well with the observation by Thomas[9] that the 3·11-MeV. gamma-ray transition between the two states is an electric dipole radiation. It also adds weight to the observed similarity in the level-structure of the mirror nuclei ^{13}C and ^{13}N.

J. Rotblat

Physics Department,
Medical College of
St. Bartholomew's Hospital,
London, E.C.1.
March 16.

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Height of the Potential Barrier in Contact Rectifiers and its Change with Temperature

In the operation of barrier-layer cells such as contact rectifiers and photo-voltaic cells, a factor of paramount importance is the height of the potential barrier at the semiconductor/metal electrode interface. Such characteristics as the photo-E.M.F., the forward and reverse resistances, and the turnover or breakdown voltage are all dependent on the barrier-height (V_D); yet the quantitative information available is rather meagre.

A simple method of determining V_D consists in observing the temperature dependence of the 'contact' or 'zero' resistance $R_0 = \lim_{u=0} u/i$, u being the applied voltage and i the resulting current. Rectifier theory indicates that R_0 should be independent of the polarity and magnitude of u, provided that $u \ll kT/e$. In practice, the magnitude of the current is found to depend on the polarity of u at temperatures above 300° K. ($kT/e \gtrsim 25$ mV.) when u exceeds approximately 1 mV. At liquid-nitrogen temperatures, on the other hand ($kT/e \sim 8$ mV.), the magnitude of the current changes only slightly with the polarity when u is as large as 50 mV.

Preliminary measurements have been made on various barrier-layer cells, such as germanium, silicon and selenium rectifiers and selenium photocells. Voltages between 0·2 and 50 mV. were applied in both the forward and reverse direction, and the current was measured with a Paschen galvanometer of sensitivity up to 30,000 mm./μamp., the greatest back-to-front current ratio accepted being 1 : 1·2. The range of resistances measurable was 10^3–10^8 ohms and, with rather low accuracy, up to 10^9 ohms. The range of temperatures from 100° to 20° C. was covered by using an oil bath, from 20° to −78° C. by acetone and solid carbon dioxide, and a further single measurement was made in liquid nitrogen. The rectifiers were held between two copper blocks, the whole being placed in a thin-walled brass tube with one of the blocks insulated by mica from the tube. A thermocouple was fitted into one of the blocks.

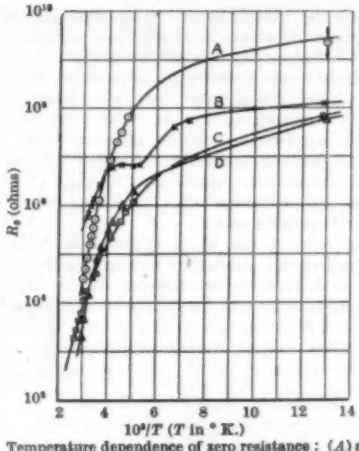

Fig. 1. Temperature dependence of zero resistance: (*A*) selenium rectifier; (*B*) selenium photocell; (*C*) silicon rectifier; (*D*) germanium rectifier

According to theory, the value of the resistance is proportional to $N^{-1}\exp(eV_D/kT)$, where N is the concentration of the free-current carriers in the bulk of the semi-conductor. Assuming N and V_D to remain constant as the temperature is varied, a graph of $\log R_0$ versus $1/T$ should yield a straight line of slope eV_D/k. The results obtained are plotted in Fig. 1. The plot is generally linear above 300° K. as far as measurements have been made; but below this temperature the resistance rises less rapidly than expected. It is assumed that the deviation from a straight line is due to a lowering of the barrier, since it is unlikely that the concentration of the current

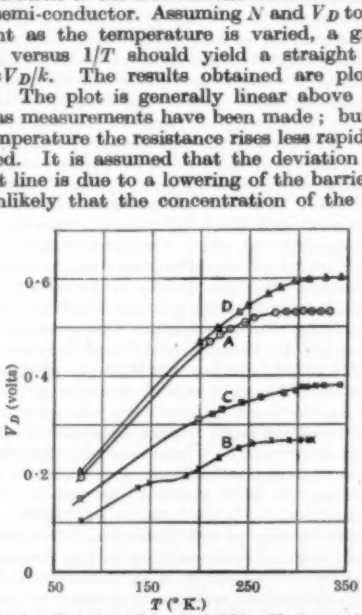

Fig. 2. Variation of barrier-height with temperature

carriers would increase with decrease in temperature. Assuming N to remain constant, $V_D = (kT/e)$ log R_θ/R_∞ can be obtained by extrapolating the linear portion of the log R_θ versus $1/T$ plot, R_∞ being the value of R_θ for $T = \infty$.

The experimental values given below for 20° C. are only preliminary, a certain amount of scatter existing between individual cells of the same type:

Barrier-cell	Germanium	Selenium	Silicon	Selenium photocell
Barrier height	0·60	0·53	0·38	0·27 volt

They are in agreement with the characteristics of these cells, the germanium point rectifier being capable of withstanding the highest inverse voltage (more than 100 V.) and the silicon rectifier the lowest (a few volts), with the selenium plate rectifier giving intermediate values and the selenium photocell very low values indeed.

Fig. 2 shows the variation of the barrier-height with temperature as derived from the curves of Fig. 1. These results show that at low temperatures V_D falls almost linearly with temperature.

E. Billig
M. S. Ridout

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston Court,
Aldermaston, Berkshire.
Feb. 21.

Derivation of the Dispersion Equation for Alfvén's Magneto-Hydrodynamic Waves from Bailey's Electromagneto-Ionic Theory

In his studies of cosmical electrodynamics, Alfvén[1] has demonstrated the existence of magneto-hydrodynamic waves in an ionized gas situated in a magnetic field. They are transverse waves and are propagated only in the direction of the magnetic field. Their velocity is $H(4\pi\mu)^{-1/2}$, where H is the magnetic field and μ is the mass density. The mass velocity of the gas is equal to the varying transverse part of the magnetic field divided by $\sqrt{(4\pi\mu)}$.

Bailey[2] has given a general theory of plane waves in an ionized gas, including the effect of static electric and magnetic fields, which is valid so long as the amplitude is sufficiently small. Consequently, some of his solutions should correspond to Alfvén's waves. This is verified here. Since the mass motion is a vital feature of Alfvén's waves, it is clear that the motion of the positive ions must not be neglected. Åström[3] has remarked on this in a recent communication, but appears to be unaware of Bailey's work. He has introduced fundamental equations which are similar to Bailey's. At the same time, Herlofson[4] has discussed the effect of the compressibility of the medium and the behaviour of waves which are propagated obliquely to the direction of the magnetic field. Alfvén and his collaborators make certain approximations which are equivalent to neglecting the time derivatives in some of the equations. Their results are therefore valid only for sufficiently low frequencies. The dependence of the wave velocity on the frequency can be obtained from Bailey's theory, and the results so obtained are given here.

The dispersion equation obtained from Bailey's theory can be expressed in terms of the following variables: ω the angular frequency and M the refractive index of the wave, N the number density of the electrons and of the positive ions, m and m' their respective masses, e the electronic charge, H the strength of the magnetic field, θ the angle between the field and the direction of wave propagation and T the temperature of the medium; also

$$P = m/4\pi Ne^2,\quad P' = m'/4\pi Ne^2,\quad \varphi = H/4\pi Nec,$$
$$\sigma = kT/4\pi Ne^2 \text{ (k being Boltzmann's constant)},$$
$$\zeta = M^2 - 1 \text{ and } Q = P + P' - 2M^2\sigma/c^2 - \omega^2(P - M^2\sigma/c^2)\,(P' - M^2\sigma/c^2).$$

For simplicity the effects of collisions are omitted. Then the general dispersion equation is

$$Q[\{\zeta(\omega^2PP' - \varphi^2\cos^2\theta) + P + P'\}\{\zeta(\omega^2PP' - \varphi^2) + P + P'\} - \omega^2\zeta^2(P - P')^2\varphi^2\cos^2\theta] + \varphi^2\sin^2\theta\,[(\zeta\omega^2PP' + P + P')\{\zeta(\omega^2(P^2 + P'^2 - PP') - \varphi^2) + P + P'\} - M^4c^{-4}\{\zeta(\omega^2PP' - \varphi^2\cos^2\theta) + P + P'\}(2c^2\sigma + \zeta\omega^2\sigma^2)] = 0. \quad (1)$$

For the limiting case in which ω vanishes, the equation can be written

$$(M^2\cos^2\theta - M_a^2)\,[M^4\cos^2\theta - M^2(M_a^2 + M_s^2 - \sin^2\theta) + M_s^2M_a^2] = 0, \quad (2)$$

where

$$M_a^2 = (P + P' + \varphi^2)/\varphi^2 \text{ and } M_s^2 = (P + P')\,c^2/2\sigma.$$

M_a is the refractive index corresponding to Alfvén's waves and M_s corresponds to the velocity of sound. Both are usually much larger than unity. Equation (2) may be compared with Herlofson's results. The roots $\pm M_a \sec\theta$ belong to purely transverse waves in which the mass motion and magnetic field are perpendicular to the static magnetic field. The second factor in (2) is symmetrical in M_a and M_s, and the roots belong to waves which are, in general, neither purely transverse nor purely longitudinal. If $M_a \gg M_s$, the roots are approximately $\pm M_s$, belonging to nearly longitudinal waves, and $\pm M_a \sec\theta$, belonging to nearly transverse waves. If $M_s \gg M_a$, the roots are approximately $\pm M_a$ and $\pm M_s \sec\theta$, but the waves approximate to longitudinal or transverse waves only when θ is near 0 or $\pi/2$. In the former case, $\pm M_a$ belongs to transverse waves and $\pm M_s \sec\theta$ to longitudinal waves, but in the latter they are interchanged.

In the case when $\theta = 0$, equation (1) can be factorized. The factor Q belongs to longitudinal waves and the other two factors belong to circularly polarized waves. Their dispersion equation can be written

$$M^2 - 1 = (M_a^2 - 1)/(1 + K\omega/\Omega)\;(1 - K\omega/\Omega'),$$

where $\Omega = eH/mc$, $\Omega' = eH/m'c$, and $K = \pm 1$, depending on the direction of circular polarization. When $\omega \ll \Omega'$, the waves of opposite circular polarization have velocities differing by the factor $1 + \omega/\Omega'$. The plane of polarization of a plane-polarized wave will therefore be rotated through an angle of $2\pi\omega/\Omega'$ in a distance of one wave-length. In the general case, when the waves are propagated obliquely to the direction of the magnetic field and ω/Ω' is not neglected, there are no purely transverse or purely longitudinal waves.

The dispersion equation (1) obtained by Bailey's method is valid for all wave-lengths much greater than $N^{-1/3}$. Thus Alfvén waves and radio waves of frequencies comparable with the electron and positive-ion plasma frequencies, $P^{-1/2}$ and $P'^{-1/2}$, or the gyro-frequencies, Ω and Ω', are covered by the one equation. In addition to obtaining the dispersion of the waves, Bailey's theory may be useful for the study of turbulence in an ionized gas in a magnetic field by means of Fourier components.

I am indebted to Prof. V. A. Bailey for suggesting this investigation and for helpful discussions.

J. W. Dungey

School of Physics,
University of Sydney. Feb. 14.

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Photoreduction in Algæ

For several years it has been known that a number of green algæ are able to carry out reduction of carbon dioxide by molecular hydrogen at low light intensities[1]:

$$CO_2 + 2H_2 \xrightarrow{\text{light}} \text{product}.$$

We have attempted to find out if this process can be observed among other algæ besides the green algæ. Gaffron[2] had tested several algæ for their capacity to carry out photoreduction and found that several green algæ were active; however, *Chlorella pyrenoidosa*, one species of the blue-green alga *Oscillatoria*, and two strains of the diatom *Nitzschia*, proved to be inactive. In the meantime, it had been demonstrated that two species of blue-green algæ[3] and a pure culture of the green flagellate *Chlamydomonas mœwusii*[4] can also carry out photoreduction. We also have had the opportunity of studying a pure culture of the red alga *Porphyridium cruentum* (isolated by J. Garnic[5]), and thalli of the marine red alga *Porphyra umbilicalis*, both of which could carry out this process. Two other marine algæ, the green alga *Ulva lactuca*, and the brown alga *Ascophyllum nodosum*, were likewise able to carry out photoreduction.

It thus appears that the ability to reduce carbon dioxide anaerobically with hydrogen in light is not restricted to the photosynthetic bacteria and the green algæ, but can be found among various species of at least four phyla of the algæ.

Algæ which have been Tested for Ability to Carry Out Photoreduction

Phylum	Algæ successfully adapted	Author	Algæ not showing photoreduction	Author
Cyanophyta (blue-green algæ)	*Synechococcus elongatus* Näg.	Ref. 3	*Oscillatoria* sp.	Ref. 1, 2
	Synechocystis sp.	Ref. 3	*Nostoc muscorum* Kützing	Ref. 7
			Cylindrospermum sp.	Ref. 7
Chlorophyta (green algæ)	*Scenedesmus obliquus* (Turp.) Kützing	Ref. 1, 2	*Chlorella pyrenoidosa* Chick.	Ref. 1, 2
	Ankistrodesmus sp.	Ref. 1, 2		
	Raphidium sp.	Ref. 1, 2		
	Ulva lactuca L.			
Chrysophyta (yellow-brown algæ)			*Nitzschia* sp. (2 strains)	Ref. 1, 2
Phæophyta (brown algæ)	*Ascophyllum nodosum* (L.) Le Jolis			
Rhodophyta (red algæ)	*Porphyra umbilicalis* (L.) J. Agardh			
	Porphyridium cruentum (C. Ag.) Näg.			

In studies with *Scenedesmus*[3], it was demonstrated that the ability to carry out photoreduction was not immediately apparent under anaerobic conditions, but that a dark-adaptation period was necessary. It is not known if an adaptive enzyme is formed during this period, or if an existing enzyme is activated so that it can react with molecular hydrogen. It is of interest that not all the algæ which can carry out photoreduction behave in the same manner in regard to this period of adaptation. We have observed that *Chlamydomonas mœwusii* either requires no adaptation period at all, or that this period is shorter than ten minutes. On the other hand, the marine algæ which we have tested thus far all required long periods of dark adaptation. We have evidence that at least one of the algæ, *Porphyridium cruentum*, will increase in dry weight and pigmentation under anaerobic conditions. We have been able to follow photoreduction in one culture for two weeks, although it was necessary to give this alga several hours of darkness every day to avoid reversion to normal photosynthesis with the evolution of oxygen.

Chlamydomonas mœwusii exhibits another striking effect: at very low intensities of light, photofermentation will take place; the cells actively evolve carbon dioxide and hydrogen from an unknown endogenous substrate. This process had been observed previously in *Scenedesmus*[3], but the relative activities of *Scenedesmus* and *Chlamydomonas* differ by almost a factor of 10. The rate of photoproduction of hydrogen by *Chlamydomonas* is of the same order of magnitude as that demonstrated by Gest and Kamen[6] for the purple bacterium, *Rhodospirillum rubrum*.

It remains to be seen if the ability to carry out this special type of photosynthesis by certain freshwater and marine algæ is an evolutionary remnant or is of importance in the distribution of algæ and in the fixation of carbon dioxide under special environmental conditions.

This study was carried out while the first author was, during the summer of 1949, Lalor Fellow at the Marine Biological Laboratories at Woods Hole, Mass., and the work was also supported by funds from the Graduate School of the University of Minnesota.

Albert W. Frenkel
Cecilia Rieger

Department of Botany,
University of Minnesota,
Minneapolis 14, Minn., U.S.A. Feb. 16.

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Amino-Acids of Certain Algæ

Pearsall and Fogg[1] have discussed the possibility of using algæ, especially *Chlorella*, as a source of food. Though cultures having a very high protein content have been produced under suitable conditions of growth, little information is available regarding the amino-acid composition of such algal proteins. Eny[2], using the technique of paper chromatography, reported that seven of the 'essential' amino-acids were absent from the proteins of *Chlorella*. These results are open to criticism on two grounds. The protein subjected to acid hydrolysis was apparently limited

to that contained in an alcoholic extract of the *Chlorella*. This could only have been a small and probably unrepresentative fraction of the total protein. The anomaly that glutamine and asparagine were present after acid hydrolysis was also reported. A more detailed study of the amino-acids present in such algal proteins therefore seemed desirable as the first step of a proposed quantitative investigation.

Two species of *Chlorella* and one of *Anabæna* have been studied in this work. *Chlorella pyrenoidosa* was grown on a culture medium containing potassium nitrate as a source of nitrogen, *Chlorella vulgaris* was supplied with ammonium nitrate, whereas *Anabæna cylindrica*, being capable of fixing atmospheric nitrogen, was not given any form of combined nitrogen. After harvesting, the algæ were washed, killed and dried at laboratory temperature. The uncombined amino-acids (free α-amino-nitrogen was usually 0·1–0·2 per cent of the dry weight) were extracted from the dried, finely ground material by 70 per cent alcohol at laboratory temperatures. 1 ml. of the aqueous alcohol was used for each 4 mgm. material. The insoluble residue, containing 3–5 per cent nitrogen, was then hydrolysed for 24 hr. at 105° with 6 *N* hydrochloric acid. The alcohol extracts and protein hydrolysates were concentrated and then desalted, finally being evaporated to dryness.

The amino-acids present in these preparations were investigated qualitatively using two-dimensional paper chromatography. Aliquots containing 20–30 μgm. α-amino-nitrogen were used for each chromatogram. Water-saturated phenol in the presence of ammonia vapour was used as the first developing solvent, and the *n*-butanol–acetic acid mixture of Partridge[3] was always the second solvent. Resolution of the leucine isomers was achieved by the method of Work[4], using *t*-amyl alcohol in the presence of diethylamine vapour. The accompanying table shows the relative intensities of the amino-acid spots obtained after ninhydrin treatment of the developed chromatograms. Tryptophan was detected on chromatograms of 5 *N* barium hydroxide hydrolysates of the algæ. Its presence was confirmed by using *p*-dimethylaminobenzaldehyde in strong hydrochloric acid as a spraying reagent, when it appeared as a blue-coloured spot.

Amino-Acids of Certain Algæ

Amino-acid	*Chlorella pyrenoidosa*		*Chlorella vulgaris*		*Anabæna cylindrica*	
	Free	Combined	Free	Combined	Free	Combined
Cystine	+	+	+	+	++	+
Aspartic acid	+	++	+	+	++	++
Glutamic acid	++	++	+++	++	+++	+
Glycine	++	++	++	++	++	++
Serine	++	++	++	++	++	++
Asparagine	−	−	+	−	−	−
Threonine	+	++	++	++	+	++
Alanine	+++	+++	+++	+++	++	+++
Glutamine	+	−	+	−	+	−
Citrulline	+	−	++	−	−	−
β-Alanine	−	−	+	−	−	−
Tyrosine	+	++	+	++	+	++
γ-Amino-butyric acid	+	−	+++	−	−	−
Lysine	+	++	+	+	+	+
Histidine	−	+	−	+	−	++
Arginine	+	++	+	++	+	++
Proline	+	++	++	++	−	+
Methionine	+	+	+	+	+	+
Valine	++	++	+	++	+	++
Phenylalanine	+	+	+	+	+	+
*iso*Leucine	+	++	+	+	−	++
Leucine	++	++	++	++	+	++
Tryptophan	−	+	−	+	−	+

+++, Strong ninhydrin colour; ++, moderately strong ninhydrin colour; +, weak ninhydrin colour; −, not detected.

The algal proteins are seen to contain the normal amino-acid constituents, only hydroxyproline being absent from the hydrolysates. The amino-acid composition of the two species of *Chlorella* appeared to be very similar, while that of *Anabæna* appeared to differ slightly in containing relatively less glutamic acid and proline. α-Amino-butyric acid was present in the alkaline protein hydrolysates; but Bremner[5] has shown this to result from the destruction of threonine under such hydrolysis conditions. During the running of the chromatograms, cystine and methionine were partially oxidized, producing spots of cysteic acid and methionine sulphoxide. No unidentified ninhydrin-reacting spots were seen in the protein hydrolysates.

Large amounts of alanine and glutamic acid appeared to be present in the free state in all the algæ. Most of the other α-amino-acids were identified in the alcohol extracts, though the amino-acid amides were never present in other than small amounts. In addition, β-alanine and γ-amino-butyric acid were found in variable amounts in *Chlorella*, their presence being confirmed by additions of 'marker' amino-acids to the extracts before chromatography. Citrulline and glutamine cannot be easily separated in the above two solvents, and form a composite spot. Using *p*-dimethylaminobenzaldehyde in *N* hydrochloric acid as a spraying reagent, citrulline was shown to be present in the *Chlorella*, appearing as a yellow spot on the chromatograms. Mild acid hydrolysis of the alcohol extracts reduced the intensity of this composite spot after ninhydrin treatment, and produced a corresponding increase in the intensity of the glutamic acid spot. This indicated the presence of glutamine. Citrulline remained after the hydrolysis, the yellow colour produced by the *p*-dimethylaminobenzaldehyde being unchanged. The alcohol extracts of all three algæ contained an unidentified blue ninhydrin-reacting spot appearing just above proline on the chromatograms, and a second such spot was seen above glutamic acid in the extract from *Anabæna*.

My thanks are due to Dr. G. E. Fogg and Mr. P. J. Syrett for growing the algæ and to Mr. R. G. Westall for a gift of γ-amino-butyric acid.

L. Fowden

Department of Botany, University College, London, W.C.1. Feb. 15.

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Various Antibiotics from one Strain of *Streptococcus lactis*

Mattick and Hirsch[1] described an antibiotic substance, nisin, produced by *Streptococcus lactis*. They showed that it was bactericidal for many Gram-positive organisms and that it was active in milk and serum. Other investigators have since been unable to confirm the observation that nisin is not significantly inactivated by serum.

Between 1945 and 1949 two commercial firms prepared nisin from cultures of the original organism used by Mattick and Hirsch. During this period cultures have also been freeze-dried, and recently some of these have been recultivated and in dilution assay found to produce more nisin in broth than the original culture. The presence of 5 per cent serum

Table 1. Antibiotics Produced by One Strain of *Str. lactis*

Year of freeze-drying	Average titre against *Str. agalactiæ* in Broth	Broth + 5 per cent serum	Ratio of activity in broth/serum
1944	1/ 83	1/45	1·8
1945	1/101	1/55	1·8
1947	1/125	1/49	2·5
1948	1/220	1/41·5	4·5
1949	1/492	1/53	9·3

removed these apparent differences, and the activities were then much the same.

Comparisons were then made between commercial and laboratory nisin preparations. The times required to kill 50 per cent of the organisms in a culture of *Strep. agalactiæ* in broth and in broth containing 5 per cent serum were determined[1]. A 'crystalline' commercial preparation (preparation *A*) was compared with a cruder nisin made from the culture dried in 1944 (preparation *L*). For preparation *A* to effect a 50 per cent kill in the presence of serum the time was increased by 264 per cent, but for preparation *L* by only 191 per cent. Similar results were found in the presence of milk. *Strep. dysgalactiæ*, previously reported resistant to nisin[1b], also behaved differently in that, turbidimetrically, 50 per cent inhibition of growth was obtained by 10–12 units/ml. of the commercial preparation *A*, but 65 units/ml. of the cruder preparation *L* were needed for the same result.

Counter-current distribution, using 100 extractions and only one pair of solvents, failed to distinguish preparations *A* and *L*. Another commercial nisin preparation (*B*) was found, using 200 extractions, to consist of two fractions, both of which were distinguishable from *A* and *L*[2].

The activity of these preparations was further tested using two of the nisin-producing strains as test-organisms (Table 2). The concentration of nisin required to give a 20 per cent inhibition of growth was measured turbidimetrically. Preparation *B* was markedly different from *A* and *L*.

Preparations *A* and *L*, which could not be differentiated from each other in the counter-current process, were readily distinguishable in this biological test.

Table 2. Differentiation of Nisin Preparations

Nisin preparation		Units/ml. nisin required to give 20 per cent inhibition of strain dried in 1944	1949
Commercial *A*		298	1547
Commercial *B*	Fraction 1	303	823
	Fraction 2	155	422
Laboratory *L*		613	1030

It is now known that similar but not identical antibiotics are produced by various types of *Strep. lactis*[4]. The above results suggest that even the same strain can produce several antibiotics.

A. Hirsch
National Institute for Research in Dairying,
Shinfield, Nr. Reading.
Feb. 9.

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Uptake of Lanthanum by a Yeast

In the course of studies of the barium metabolism of larval *Drosophila* which it is planned to report in full elsewhere, we have found that larvæ on a medium containing barium-140 showed lanthanum-140 enrichment if the medium had been inoculated with Texas *Y*-2 strain of yeast[1] twenty-four hours before adding the larvæ, but barium-140 enrichment if the larvæ had been placed directly on the sterile food. These enrichments were measured by means of deviations in the shape of the curves of radioactive decay for the chain $^{140}Ba \rightarrow {}^{140}La \rightarrow {}^{140}Ce$, as has been clearly described[2] for the strontium-90–yttrium-90 chain. The observation appeared explicable on the assumption that the yeast cells were selecting lanthanum from the medium, while the larvæ, though preferring to feed on yeast cells, preferentially absorb barium.

To explore this possibility the yeasts were grown in shake-cultures on two media, one the fluid version of yeast beef broth agar[3] and the other Kalmus's[4] *Drosophila* medium modified by omission of agar, and substitution on a molar basis of propionic acid for half the tartaric acid. To each medium, carrier-free barium-140–lanthanum-140, in radioactive equilibrium, was added, and a drop of live yeast suspension.

Cells taken after 2, 4, 6, 24 and 72 hr. from both media, and washed once with non-radioactive medium, showed striking lanthanum enrichments, the decay curves of those from beef broth corresponding to six parts lanthanum-140 plus four parts barium-140–lanthanum-140 equilibrium, while those from the Kalmus medium corresponded to 9 parts lanthanum-140 plus 1 part barium-140–lanthanum-140 equilibrium. On the latter medium, growth was very slight. In one set of samples which were washed four times, it was found that the radioactivity of the fourth wash solution indicated barium to be removed slightly more easily than lanthanum.

Other experiments, still in progress, indicate that a fraction of both isotopes is retained even after twenty-four hours growth in clean medium, and that in the case of lanthanum this fraction is only slightly reduced by the presence, in the clean medium, of stable lanthanum acetate at concentrations of 0·36–0·72 millimolar.

Analytical studies by Richards and Troutman[5] indicated lanthanum accumulation by *Saccharomyces cerevisiæ*. Texas *Y*-2 is reported[6] as having been tentatively identified as a non-pathogenic form of *Candida albicans*. It appears that lanthanum uptake may be a common property of yeast growth, and experiments are now in progress to ascertain how far this property may be used as a tool in exploring the biochemical properties of the lanthanides.

This investigation was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

V. T. Bowen
Ann C. Rubinson

Biology Department,
Brookhaven National Laboratory,
Upton, L.I., N.Y.

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Presence of Enteramine in the Skin of Amphibia

THE presence of enteramine has already been demonstrated (by means of colour reactions, pharmacological reactions and, quite recently, by the method of chromatography on paper[1]) in acetone- and alcohol-extracts of posterior salivary glands of *Octopus vulgaris* and *Eledone moschata*[2,3], of the hypobranchial body of *Murex trunculus* and *Murex brandaris*[4], of the intestine of *Ciona intestinalis* and *Tethium plicatum*[5], as well as of mammalian intestinal mucosa and spleen[6,7]. We now find that the skin of Amphibia should be included in the list of organs and tissues containing enteramine.

So far, acetone extracts of the skin of *Bufo bufo bufo*, *Discoglossus pictus*, *Rana esculenta*, *Hyla arborea*, *Salamandra maculosa* and *Triton cristatus* have been examined. The parathyroid glands of *Bufo* were extracted separately from the remaining skin. After cleaning with petroleum ether and suitable concentration (in order that 1 ml. liquid should correspond to 1–10 gm. fresh tissue), extracts were chromatographed on Whatman No. 1 paper, using the following solvents: *n*-butanol saturated with *N* hydrochloric acid, *n*-butanol saturated with 3–5 per cent ammonium hydroxide, butanol – acetic acid – water mixture, amyl alcohol – pyridine – water mixture (2:2:1). *n*-Butanol saturated with *N* hydrochloric acid was employed as first solvent in bi-dimensional chromatography, followed by the amyl alcohol – pyridine – water mixture.

Numerous uni- and bi-dimensional control chromatograms were run with extracts of posterior salivary glands of *Octopus vulgaris* and *Eledone moschata*, and also with alcoholic solutions of pure bufotenine, bufotenidine and bufothionine. Numerous 'mixed' chromatograms were likewise obtained by simultaneously applying, on the same point of the paper, two or more skin extracts of different Amphibia, with or without addition of salivary extract of *Octopus vulgaris* and of pure indolalkylamines.

On the chromatograms of the skin extracts of four out of six Amphibia investigated (negative or doubtful results were obtained from *Triton cristatus* and *Bufo bufo bufo*) it was possible to demonstrate a spot due to enteramine (spot *E*). Indeed, spot *E* shows all the characteristic colour reactions given by the enteramine spots obtained with salivary extracts of *Octopus vulgaris* and *Eledone moschata*[1] and cannot be distinguished from these comparison spots. Further, R_F values of spot *E* agree satisfactorily with R_F values of the enteramine spots obtained with salivary extracts, with all the solvents tested[1].

On 'mixed' chromatograms, uni- and bi-dimensional, of skin extracts of Amphibia and salivary extracts of Octopoda, the enteramine spot is always unique, and its intensity and extension is equal to the sum of the enteramine spots which should develop if the two extracts were chromatographed separately.

Spots given by bufotenine, bufotenidine, bufothionine and dehydrobufotenine show R_F values clearly different from those of spot *E* and of enteramine comparison spots, particularly when using as solvent *n*-butanol saturated with 3–5 per cent ammonium hydroxide[8].

The eluates of spot *E* possess all the peculiar pharmacological actions of enteramine: they stimulate the isolated œstrous uterus of rats and mice, the urinary bladder of dogs, whether isolated or *in situ*, and they inhibit diuresis in hydrated rats[9]. From a qualitative point of view, no difference exists between the pharmacological reactions induced by eluates of spots *E* and those induced by eluates of control enteramine spots. From a quantitative point of view, the pharmacological response is in all cases identical for *E* eluates and enteramine eluates giving *in vitro* a coupling reaction of the same intensity with the diazonium salt of *p*-nitroaniline (acid medium).

The enteramine contents in equal weights of amphibian skin give the following per cent figures, when referred to a standard salivary extract of *Octopus vulgaris* (summer 1950 extract, prepared from 14·3 kgm. fresh tissue): *Discoglossus pictus*, 95–110 per cent, *Hyla arborea*, 45–55 per cent, *Rana esculenta*, 3–5 per cent, *Salamandra maculosa*, 3 per cent.

The presence of enteramine in the skin of Amphibia is interesting for many reasons. First, it allows us to include in the enteramine cell system (enterochromaffine system intended in a broad sense) also a part of the chromaffine and argentaffine cells of the amphibian skin, already studied histochemically by one of us (Vialli[10]); secondly, because this fact fits in with many established data we are collecting in order to explain the biological significance of enteramine.

The coupling reaction with diazonium salts and the other colour reactions studied in previous investigations[1] develop, on chromatograms of amphibian skin, not only the enteramine spot, but also a number of other spots differing for each extract. We shall consider them further in future work which we intend to carry out on a much wider comparative basis than we have done so far. We shall also examine the chemical and pharmacological relations existing between enteramine and other active constituents, particularly basic constituents, of the cutaneous secretion of Amphibia.

V. ERSPAMER

Institute of Pharmacology,
University of Bari.

M. VIALLI

Institute of Comparative Anatomy,
University of Pavia.

Feb. 20.

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Aldolase Activity in Zinc-deficient Plants

DISTURBANCES in the metabolism of phosphate and of carbohydrate in zinc-deficient tomato plants led Reed[1] to suggest the occurrence of "some block in the enzyme system which controlled a fundamentally important process in the utilization of sugars".

Warburg and Christian[2] had found a relationship between zinc and the enzyme zymohexase (aldolase) in yeast. Reed[1] suggested that a similar relationship might exist in a complex organism such as a tomato plant.

For these reasons an examination was made of the aldolase activity[3] of oat plants (*Avena sativa* var. Algerian) which had been grown in copper-deficient and in zinc-deficient water cultures. Lesions of deficiency were apparent in both series. While the aldolase activity in copper-deficient plants did not differ significantly from that in the controls, aldolase activity in the zinc-deficient plants was strikingly decreased. An assay of subterranean clover plants (*Trifolium subterraneum* L.) grown in water culture also demonstrated that the aldolase activity in the zinc-deficient clover plants was considerably lower than that in the controls (see table).

Plants	Control Qx*	Copper-deficient Qx*	Zinc-deficient Qx*
Oats (*Avena sativa* var. Algerian)	6·6	7·3	0·95
	8·1	7·1	1·3
	8·4	7·0	4·6†
	5·4	6·2	Av. 2·3
	8·3	6·0	
	Av. 7·4	Av. 6·7	
Subterranean clover (*Trifolium subterraneum*)	2·4		0·42
	2·2		0·28
	1·9		0·32
	Av. 2·2	—	Av. 0·34

* $Qx = Q/m$, where Q is c.mm. of substrate changed/hr./mgm. dry matter, which, in this instance, is micromoles (×22·4) of hexose diphosphate decomposed/hr./mgm. dry matter; and m is the constant derived from the relationship between alkali-labile phosphorus (triose phosphorus) and colour density ($2 - \log T$ at 540 mμ) of the coloured 2-4-dinitrophenylhydrazine-triose complex (ref. 3), that is, P (in μgm.) $= m(2 - \log T)$.

† Deficient in both copper and zinc. Predominant symptoms those of zinc deficiency.

Thus one of the reasons for failure of plants grown in zinc-deficient media is the breakdown of normal carbohydrate metabolism due to decreased activity of the enzyme, aldolase, which catalyses the reversible reaction between hexose diphosphate and triose phosphate.

Further details will be published elsewhere.

T. A. F. Quinlan-Watson

Division of Biochemistry and
General Nutrition,
Commonwealth Scientific and
Industrial Research Organization,
Adelaide.
Jan. 23.

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Vitamin B_{12} as a Growth Factor for Soil Bacteria

Studies of the nutritional requirements of soil bacteria isolated on a non-selective basis[1] have shown the presence of a well-defined group of organisms dependent upon soil extract for maximum growth. These bacteria show no growth, or at best sub-maximal growth, in media containing sugars and inorganic salts, supplemented by yeast extract or combinations of amino-acids and vitamins (not including B_{12}). Though the relative incidence of this group may vary with the soil type, soil management and the season[2], the chief factor affecting the proportion of these organisms is believed to be the growing plant, investigations with a variety of crops[3,4] having shown a lowered relative incidence in the rhizosphere, attributable to a preferential stimulation by the plant root of bacteria with simpler nutritional needs. However, in soil beyond the zone of influence of the root, this group has been found to comprise 8–35 per cent of the bacteria in the soils examined.

In the course of taxonomic and physiological studies of bacteria incapable of growth in the yeast extract medium, but showing abundant growth upon the addition of soil extract, the ability of vitamin B_{12} to replace soil extract as growth-promoting factor was determined. Of 534 bacterial strains, isolated on a non-selective basis from field soil, 75 strains, or 14·0 per cent, fell into this special group. Replacement of soil extract by vitamin B_{12}, added to give a concentration of 2 mμgm. per ml., permitted optimum growth of 26·7 per cent, and sub-maximal growth of 28·0 per cent of this group. In the case of the remainder, vitamin B_{12} gave no growth response (see table).

	No.	% of (1)	% of (2)
(1) Total isolates from soil	534		
(2) No growth in yeast extract medium, maximum growth with soil extract	75	14·0	
(*a*) Maximum growth with vitamin B_{12}	20	3·7	26·7
(*b*) Sub-maximal growth with vitamin B_{12}	21	3·9	28·0
(*c*) No growth with vitamin B_{12}	34	6·4	45·3

Since soils of the type studied give normally bacteria counts of 50–100 millions per gram, as determined by plating methods, it is estimated that approximately 4–8 million bacteria (per gram) which depend upon growth-promoting substances in soil may utilize vitamin B_{12} as an essential nutrilite. This vitamin is known to be present in soil, and, though it may be added by application of organic manures of animal origin, synthesis by other soil micro-organisms is suggested as an important source of supply. Recent studies in this laboratory[5], in which special selective media were employed, have shown 70 per cent of the bacteria isolated from local cultivated soil and 84 per cent of those from uncultivated soils of northern Canada to be capable of synthesizing vitamin B_{12}. However, the finding that many bacteria requiring soil extract show no response to the vitamin (see table) suggests the presence in soil of other as yet unidentified bacterial growth-promoting substances.

A. G. Lochhead
R. H. Thexton

Division of Bacteriology and Dairy Research,
Science Service,
Department of Agriculture,
Ottawa.
Feb. 2.

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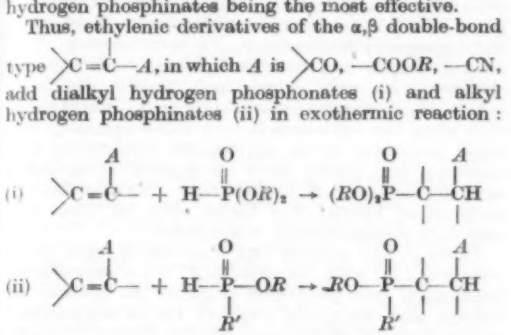
Formation of C—P Bonds by Addition of Di-Alkyl Hydrogen Phosphonates and Alkyl Hydrogen Phosphinates to Activated Ethylenic Derivatives

In the course of a study in these laboratories of new methods for the formation of C—P bonds, the possibility was considered of addition of organic phosphorus compounds of the $>\!\overset{\|}{\underset{O}{P}}\!-\!H$ type to activated ethylenic derivatives. This would offer a new approach to a synthesis of various organic oxyacids of phosphorus. Recently, we have been able to show that the reaction is promoted by basic catalysts, sodium derivatives of hydrogen phosphonates and hydrogen phosphinates being the most effective.

Thus, ethylenic derivatives of the α,β double-bond type $>\!C\!=\!C\!-\!A$, in which A is $>\!CO$, $-COOR$, $-CN$, add dialkyl hydrogen phosphonates (i) and alkyl hydrogen phosphinates (ii) in exothermic reaction:



Addition takes place in a sense opposed to Markownikow's rule, resembling the Michael type of reaction. The temperature of the reaction was kept by external cooling below 25° and often as low as 10°.

Addition products forming colourless viscous high-boiling liquids were isolated in good yield and then hydrolysed to give the corresponding crystalline phosphonic and phosphinic acids.

Most of the products obtained have not hitherto been described in the chemical literature and their proposed structures will be further investigated. As an example of the application of this novel method the following reactions can be reported.

Vinyl cyanide (I) adds dibutylhydrogenphosphonate, $(n\text{-BuO})_2PO.H$ (II), dibutyl-β-cyanoethylphosphonate, $(n\text{-BuO})_2PO.CH_2CH_2CN$ (III), being formed in 84 per cent yield (b.p. 143–144°/0·8 mm. mercury; found: C, 53·2; H, 9·1; N, 5·7; P, 12·8; $C_{11}H_{22}O_3NP$ requires: C, 53·4; H, 9·0; N, 5·7; P, 12·5 per cent). Hydrolysis of (III) by concentrated hydrochloric acid gave β-phosphonopropionic acid, $(HO)_2PO.CH_2CH_2COOH$ (IV), with 87 per cent yield (colourless plates from water; m.p. 167–168°; found: P, 20·1; calc. for $C_3H_7O_5P$: P, 20·1 per cent). (IV) was recognized as β-phosphonopropionic acid, described by Arbusov and Dunin (ref. 1).

(I) and diethylhydrogenphosphonate, $(EtO)_2PO.H$, gave diethyl-β-cyanoethylphosphonate $(EtO)_2PO.CH_2CH_2CN$ (V) with 73 per cent yield (b.p. 127–128°/1·5 mm. mercury; found: P, 16·0; $C_7H_{14}O_3NP$ requires: P, 16·2 per cent). Hydrolysis of (V) gave (IV) (identified by mixed melting point with an authentic specimen).

(I) and monobutylphenylhydrogenphosphinate $(n\text{-BuO})C_6H_5PO.H$ (VI) gave monobutylphenyl-β-cyanoethylphosphinate $(n\text{-BuO})C_6H_5PO.CH_2CH_2CN$ (VII) in 70 per cent yield (b.p. 110–113°/0·01 mm. mercury; found: C, 61·6; H, 7·4; N, 5·6; P, 12·3; $C_{15}H_{22}O_2NP$ requires: C, 62·1; H, 7·2; N, 5·6; P, 12·3 per cent). Hydrolysis of (VII) gave β-phenylphosphinopropionic acid, $HOC_6H_5PO.CH_2CH_2COOH$ (VIII), in 88 per cent yield (colourless needles from water, m.p. 159–160°; found: C, 50·5; H, 5·4; P, 14·6; $C_9H_{11}O_4P$ requires: C, 50·5; H, 5·2; P, 14·5 per cent).

Ethyl crotonate and (II) gave ethyl dibutylphosphono-β-butyrate, $(n\text{-BuO})_2PO.CHMeCH_2COOEt$ (IX), in 82 per cent yield (b.p., 83–84°/0·02 mm. mercury; found: C, 54·3; H, 9·6; P, 10·0; $C_{14}H_{29}O_5P$ requires: C, 54·5; H, 9·5; P, 10·05 per cent). Hydrolysis of (IX) gave β-phosphonobutyric acid, $(HO)_2PO.CHMeCH_2COOH$, with 85 per cent yield (colourless micro-needles from acetic acid; m.p. 149–150°; found: C, 28·7; H, 5·6; P, 18·4; $C_4H_9O_5P$ requires: C, 28·6; H, 5·4; P, 18·4 per cent).

Methyl acrylate (X) adds (II); the crude product was hydrolysed as above, yielding (IV), identified by mixed melting point.

(X) and (VI) gave methyl-β-monobutylphenylphosphinopropionate, $n\text{-BuOC}_6H_5PO.CH_2CH_2COOMe$ (XI), with 75 per cent yield (b.p., 108°/0·02 mm. mercury; found: C, 58·9; H, 7·6; P, 10·8; $C_{15}H_{23}O_4P$ requires: C, 59·1; H, 7·45; P, 10·9 per cent). Hydrolysis of (XI) gave (VIII), identical with the specimen obtained by hydrolysis of (VII).

Ethyl cinnamate and (II) gave ethyl β-dibutylphosphono-β-phenylpropionate, $(n\text{-BuO})_2PO.CHPhCH_2COOEt$ (XII), with 40 per cent yield (b.p. 123°/0·02 mm. mercury; found: C, 61·3; H, 8·7; P, 8·2; $C_{18}H_{29}O_5P$ requires: C, 61·7; H, 8·4; P, 8·8 per cent). Hydrolysis of (XII) gave β-phosphono-β-phenylpropionic acid, $(HO)_2PO.CHPhCH_2COOH$, in very good yield (colourless needles from acetic acid; m.p. 200–202°; found: C, 46·6; H, 4·9; P, 13·2; $C_9H_{11}O_5P$ requires: C, 47·0; H, 4·8; P, 13·5 per cent).

Benzylideneacetone and (II) gave 1-phenyl-1-dibutylphosphono-butan-3-on, $(n\text{-BuO})_2PO.CHPhCH_2.CO.CH_3$, with 68 per cent yield (b.p., 117°/0·02 mm. mercury; found: C, 63·3; H, 8·7; P, 8·9; $C_{18}H_{29}O_4P$ requires: C, 63·5; H, 8·6; P, 9·1 per cent).

A full account of this investigation will be published elsewhere. We are indebted to Prof. O. Achmatowicz for his interest and for discussions. One of us (J. M.) desires to thank the Science Support Committee of the Ministers' Council of the Polish Government for a fellowship which enabled him to take part in the research.

B. Bochwic
J. Michalski

Organic Chemistry Department,
Institute of Technology,
Lodz, Poland.
Feb. 7.

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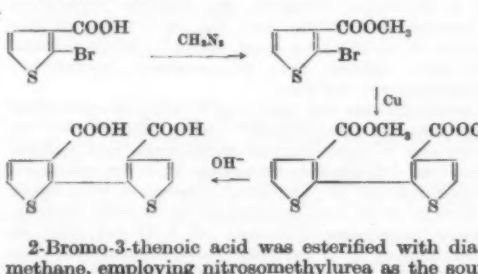
Symmetrical Bi-Aromatics

Recorded instances of the preparation of symmetrically substituted bithienyls appear only scattered in the literature[1]. Furthermore, no work has been published concerning the symmetrically substituted 3,3′-bithienyls.

In the course of studies on the chemistry of heterocyclics[2], initiated in this Department, it became necessary to focus our attention on the preparation of 3,3′-dithenic acid, *via* the readily available 2-halo-3-thenoic acids[3].



2-Bromo-3-thenoic acid was esterified with diazomethane, employing nitrosomethylurea as the source of the diazomethane. Evaporation of the ethereal solution and subsequent fractionation afforded methyl 2-bromo-3-thenoate (b.p. 114–115°/4 mm.; calc. for $C_6H_5O_2SBr$: C, 32·59; H, 2·28; found: C, 32·85; H, 2·45).

This ester was heated and afterwards treated, in the usual manner, with excess Baker's precipitated copper. Upon cooling, the solid mass was extracted with ether and filtered. Evaporation of the ethereal solution left methyl 3,3′-dithenate as a residue, which crystallized from ethyl alcohol in yellow plates (yield, 24 per cent; m.p. 145–147° (all melting points were obtained with the Fisher–John apparatus); calc. for $C_{12}H_{10}O_4S_2$: C, 51·05; H, 3·57; found: C, 50·72; H, 3·49).

Hydrolysis of methyl 3,3′-dithenate was accomplished with dilute alkali. Acidification yielded the desired acid, which was purified by sublimation *in vacuo* (m.p. 175–185° decomp.; calc. for $C_{10}H_6O_4S_2$: C, 47·23; H, 2·38; found: C, 47·15; H, 2·31).

The successful application of 2-bromo-3-thenoic acid to this type of condensation is the basis for the current extension of this work to the preparation of mixed bi-aromatics containing the thiophene, furane and benzene rings, existing possibly in two stereoisomeric forms due to restricted rotation.

These studies are carried out under the auspices of the Office of Naval Research.

Louis J. Owen
F. F. Nord

Department of Organic Chemistry
and Enzymology,
Fordham University,
New York 58, N.Y.
Feb. 5.

[1] Steinkopf, W., *et al.*, *Ann.*, **546**, 180 (1941); **543**, 128 (1940); **541**, 260 (1939); **543**, 119 (1940); **545**, 45 (1940); **541**, 238 (1939).
[2] King, W. J., and Nord, F. F., *J. Org. Chem.*, **13**, 635 (1948). Owen, L. J., and Nord, F. F., *ibid.*, **15**, 988 (1950).
[3] Campaigne, E., and Lesuer, W. M., *J. Amer. Chem. Soc.*, **71**, 333 (1949).

Configurational Activity

Since the simple salts of optical antipodes d^+X' and l^+X' have equal solubilities, it follows that the activity products are equal, and hence $a_d{}^+ = a_l{}^+$ in the saturated solutions. Electrolytes such as sodium nitrate change the activities of both enantiomeric ions to the same extent. A number of observations, to be published shortly, have led us to the conclusion that a specific effect can be exerted on one enantiomeric ion by the addition of an electrolyte containing an optically active anion or cation. As a result, in such solutions, $a_d{}^+ \neq a_l{}^+$, and a number of interesting consequences follow, such as the possibility of carrying out a resolution without the discrete separation of diastereoisomerides, and the movement of the position of equilibrium in an optically labile system. We have named this phenomenon tentatively 'configurational activity'.

The solubilities of *d*- and *l*-tris 1 : 10, phenanthroline ruthenium II perchlorate[1] were determined in ammonium *d*-bromcamphor sulphonate and sodium potassium *d*-tartrate solutions up to 2 per cent concentration at 25° C. The solubility curves were found to diverge from zero concentration of each solvent, reach a maximum difference of 3–3½ per cent at approximately 1–1½ per cent concentration and then commence to converge. It appears that the normal non-specific activity effect tends to outweigh the specific configurational effect at high ionic strengths. The dextro form was the more soluble in the former solvent (*d*-form, 0·244 gm.; *l*-form, 0·236 gm./100 gm. 1 per cent solvent), the lævo in the latter solvent (*d*-form, 0·205 gm.; *l*-form, 0·211 gm./100 gm. 1 per cent solvent).

Tris-2 : 2′, dipyridyl nickel iodide exists in antipodal forms, which are less soluble than the inactive iodide. The substance is optically labile (half-life, 15 min. at 17° C. [2]), and has been shown to exhibit the phenomenon of first-order asymmetric transformation[3]. The racemic chloride was dissolved in 1½ per cent ammonium *d*-bromcamphor sulphonate, or *l*-quinine bisulphate, or *d*-tris-ethylenediamine cobalt (III) chloride at 5° C., and immediately fractionally precipitated with sodium iodide solution. The least soluble fraction was found to be dextrorotatory ($\alpha = 0{\cdot}1°$ approx. sat. sol.); the most soluble, lævorotatory. When the mixture was allowed to stand at 20° C. for a day, the rotation of the mixture, due to the added optically active substance, was found to have moved in the lævo direction. On precipitation, as before, the least soluble fraction had no rotation, but the most soluble was lævorotatory. At the instant of addition of the extraneous optically active ion, the concentrations of the enantiomeric ions of the nickel complex were equal; but the activity of the lævo ion was reduced more than the activity of the dextro ion. The dextro iodide was therefore precipitated first. On standing, the equilibrium between the antipodes moved until the activities became equal. This occurred at the expense of the concentration of the dextro form, with the consequent development of a lævo rotation. The racemic iodide was thus precipitated first, because the activities were equal, and, finally, the lævo iodide, which was the excess component. It is evident that when the substance is very labile optically, the rapid movement of the asymmetric equilibrium will eliminate the excess lævo (or dextro) component, and all fractions will be inactive. This was the experience of Pfeiffer and Quehl with the zinc and cadmium phenanthroline complexes[4,5].

Pauling[6] has pointed out that the charges on a complex ion such as $Fe(CN)_6{}^{''''}$ are distributed fractionally over peripheral atoms of the ligands. It follows that when the complex ion is asymmetric in the classical sense, such as the $Co(en)_3{}^{+++}$ ion, the fractional charge distribution leads to mirror-image electric fields about the antipodal forms. In organic compounds, as suggested somewhat diffidently by Betti[6], the asymmetry of the carbon atom in the simplest case is not due to four different masses or groups attached to carbon but to four different dipoles. The molecule thus has an asymmetric antipodal field, but of smaller intensity due to the smaller charges involved. It is considered that the configurational activity effect is due to different interactions between asymmetric electric fields of the ions. The maximum effect is to be anticipated with multiply-charged complex ions. The potential of the cell $d\text{-Os(dipy)}_3{}^{++}/d\text{-Os(dipy)}_3{}^{+++}$ and the corresponding lævo and racemic cells in the presence of optically active ions is at present being studied.

As well as offering an explanation of many phenomena observed in the separation of enantiomorphs[7], it is believed that the concept of configurational activity should be of biological importance, since the rates of many enzyme processes should be changed by the addition of inert optically active complex ions.

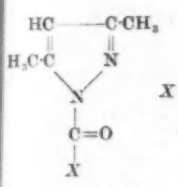
F. P. Dwyer
E. C. Gyarfas
M. F. O'Dwyer

Department of Chemistry,
University, Sydney.
Jan. 25.

[1] Dwyer, F. P., and Gyarfas, E. C., *J. Roy. Soc. N.S.W.*, **83**, 170 (1949).
[2] Morgan, G. T., and Burstall, F. H., *J. Chem. Soc.*, 2213 (1931).
[3] Pfeiffer, P., and Nakatsuka, Y., *Ber.*, **66**, 415 (1933).
[4] Pfeiffer, P., and Quehl, K., *Ber.*, **64**, 2667 (1931).
[5] Pauling, L., *J. Chem. Soc.*, 1461 (1948).
[6] Betti, R., *Trans. Farad. Soc.*, **26**, 357 (1930).
[7] McKenzie, A., *J. Chem. Soc.*, **107**, 449 (1915).

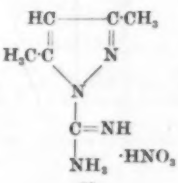
Carbamidine-substituted Pyrazoles

THE ease with which 1-substituted pyrazoles may be converted into the free imino compounds varies with the nature of the 1-substituent and the reacting substance. Thus, 1,3,5-trimethyl pyrazole may be nitrated[1] and 1-phenyl pyrazole reduced to the pyrazoline[2] without loss of the N-methyl or N-phenyl groups respectively. On the other hand, pyrazoles of the 1-carbamyl or 1-phenylcarbamyl type, (I), derived from the acyl hydrazides, semicarbazide[3] and 4-phenylsemicarbazide[4], are much less stable and readily give the free imino derivatives.



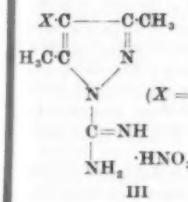
$X = NH_2$, or $= NHC_6H_5$.

I



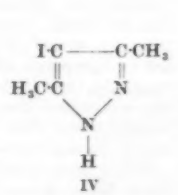
II

Aminoguanidine, although of the acyl hydrazide class, has shown differences from semicarbazide in many respects. It possesses considerably stronger basic powers. It yields imino-triazenes with aromatic β-diketones, whereas semicarbazide forms osazones[5] and its azide, guanyl azide, can be cyclized to a 5-substituted tetrazole, although, under similar conditions, carbamyl azide does not give this reaction[6]. Our investigation extends the comparison of the acyl hydrazides to the pyrazole series and deals with the stability and reactivity of the carbamidine type prepared by Thiele[7]. 3,5-Dimethyl 1-carbamidine nitrate pyrazole (II) has been investigated as typical of the class. It is more stable than the related carbamides, approaching that of compounds of the 1-aryl or 1-alkyl type. It reacts with chlorine and bromine, giving the 4-chloro and 4-bromo derivatives respectively (III). With iodine, 'deguanylation' as well as substitution takes place, the product obtained being 4-iodo, 3,5-dimethyl pyrazole (IV).

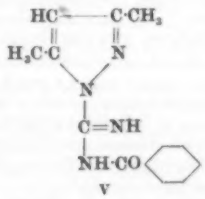


(X = Cl, Br)

III



IV



V

An anomalous action with iodine is also observed in the halogenation of the N-benzoyl-carbamidine pyrazole (V). With this substance, 4-chloro- and 4-bromo-substituted compounds are readily formed, whereas iodine (or methyl iodide) yields a compound, free of halogen, with an empirical formula C_4H_4NO. Incidentally, this similarity of action between iodine and methyl iodide is not observed with the carbamidine pyrazole.

Attempted hydrazinolysis of the carbamidine pyrazole yields unexpected results. During the reaction, acetyl acetone and 3,5-dimethyl pyrazole may be detected in the escaping vapours. The residue consists mainly of aminoguanidine nitrate. With an excess of hydrazine hydrate (4 moles), triaminoguanidine nitrate is the main product. The benzoyl-substituted-carbamidine pyrazole, under similar conditions, is unchanged by hydrazine hydrate. This is the first recorded example that we have been able to find of ring fission in the pyrazole series by hydrazine hydrate. It is analogous to the replacement by hydrazine hydrate of aminoguanidine[8] or biaminoguanidine[9] from their benzal derivatives, and to the displacement of hydroxylamine from the *iso*-oxazoles by treatment with hydrazines[10].

3,5-Dimethyl 1-carbamidine nitrate pyrazole has been characterized by its benzoyl and *p*-toluene-sulphonyl chloride derivatives, as well as by the formation of stable picrates, flavianates and chloroplatinates. The free base has also been obtained in a pure, crystalline form. In some respects the carbamidine pyrazole is very resistant to chemical action; for example, refluxing with acetic anhydride in glacial acetic acid, or heating at 50° C. (for 2 hr.) with an equimolar quantity of fuming nitric acid does not appreciably affect it. The presence of sulphuric acid during nitration produces deguanylation, however, the product being 3,5-dimethyl 4-nitro pyrazole. Sulphuric acid alone, under certain conditions, also causes fission of the carbamidine group. Other reagents, for example, boiling concentrated aqueous potassium hydroxide or sodium and ethyl alcohol, can also bring about the same result.

F. L. SCOTT
C. M. B. MURPHY
J. REILLY

Chemistry Department,
University College,
Cork.
Feb. 17.

[1] Knorr, *Ann.*, **279**, 234 (1894).
[2] Balbiano, *Gazz. chim. ital.*, **18**, 358 (1888).
[3] Posner, *Ber.*, **34**, 3979 (1901). von Auwers, *Ber.*, **58**, 2075 (1925). Dornlow and Peterlein, *Ber.*, **82**, 257 (1949).
[4] Wheeler and Norton, *J. Amer. Chem. Soc.*, **50**, 2488 (1928).
[5] Thiele and Bihan, *Ann.*, **302**, 299 (1898). Thiele and Strange, *Ann.*, **283**, 27 (1894). De, *Quart J. Ind. Chem. Soc.*, **4**, 183 (1927).
[6] Hantzsch and Vagt, *Ann.*, **314**, 339 (1906).
[7] Thiele and Dralle, *Ann.*, **302**, 275 (1898). See also De and Rakshit, *J. Ind. Chem. Soc.*, **13**, 509 (1936).
[8] O'Connor, Horgan and Reilly, *J. App. Chem.*, **1**, 91 (1951).
[9] Scott, F. L., and O'Sullivan, D. A. (unpublished work).
[10] Musante, *Gazz. chim. ital.*, **72**, 537 (1942).

Adsorption of Water Vapour on Solid Surfaces

IN their recent communication[1], Dr. F. P. Bowden and Mr. W. R. Throssell reported conclusive quantitative evidence against the view at one time widely held that metal surfaces invariably adsorb water vapour strongly from air at high relative humidities. In my work of some years ago on the gravimetric determination of thin oxide films, more especially those formed at room temperatures, no attempt to

determine adsorption *per se* was made; nevertheless, the general results led strongly to the view (for which confirmation was forthcoming in contemporary literature[2]) that adsorption of water vapour is negligible provided that both the metal surface and the atmosphere are free from contamination. Iron was found to be particularly susceptible to the presence of disperse solid particles (for example, traces of ammonium sulphate[3]), while nickel provided an extreme case of susceptibility to gaseous pollution (for example, traces of sulphur dioxide[4]).

Experiments carried out about the same time but hitherto unpublished appear to bear upon Bowden and Throssell's observations. Polished and degreased nickel surfaces were submitted to two-stage exposures, (*a*) to purified air saturated with water vapour, (*b*) to purified and dried air to which had been added a trace of sulphur dioxide. No visible change was produced at the end of either the first or the second periods of exposure. The experiment was then reversed, the specimens (polished and cleaned as before) being first exposed to the dry air containing a trace of sulphur dioxide and, secondly, to air saturated with water vapour; between the two exposures the specimens were placed in a vacuum desiccator which was evacuated to remove sulphur dioxide other than any held by adsorption on the metal surface. No visible change resulted from the first exposure; on transference to the saturated atmosphere, however, the specimens became rapidly covered with a visible film (spontaneous 'fogging'). The published work showed the presence of free sulphuric acid in such films, arising no doubt from the catalytic activity of the metal. Although entirely qualitative, the results appear to be significant as showing that adsorption of sulphur dioxide must precede any adsorption of water vapour; they may, indeed, provide, a clue to the nature of the impurity responsible for the adsorption observed in Bowden and Throssell's experiments.

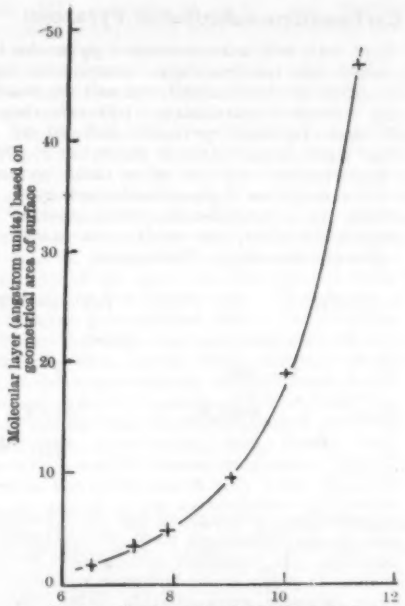
W. H. J. Vernon

Chemical Research Laboratory,
(Department of Scientific and Industrial Research),
Teddington, Middlesex.
May 2.

[1] *Nature*, **167**, 601 (1951).
[2] McBain, J. W., "The Sorption of Gases and Vapours by Solids", 316 (1932).
[3] Vernon, W. H. J., *Trans. Farad. Soc.*, **23**, 159 (1927); **31**, 1692 (1935).
[4] Vernon, W. H. J., *J. Inst. Metals*, **48**, 121 (1932).

It is interesting to note that the measurements (by weighing) of water vapour on metal surfaces reported by Dr. F. P. Bowden and W. R. Throssell[1] are in agreement with measurements (by insulation resistance determination) published twenty-one years ago[2] for the adsorption of water vapour on clean and contaminated mica surfaces. The accompanying graph has been plotted from these measurements by assuming a sodium chloride 'contamination' which would give a measurable insulation resistance for a thickness of electrolyte of the order of molecular dimensions (10^{-8} cm.)—a concentration of as low as 10^{-6} gram-equivalent per c.c. suffices.

In our paper we find: "These observations mean that a fresh, clean mica surface, in an atmosphere of clean, unsaturated water vapour, takes on a measurable layer of moisture only with the greatest difficulty; indeed, they seem to indicate that if perfect cleanliness were attainable, no measurable layer would form until saturation pressure was reached".



Adsorption of water vapour on a mica surface freshly formed in air. Temperature, 20·5° C.; saturation pressure, 18 mm. of mercury

James M. Macaulay

Department of Natural Philosophy,
Royal Technical College,
Glasgow, C.1. May 10.

[1] Bowden, F. P., and Throssell, W. R., *Nature*, **167**, 601 (1951).
[2] Macaulay, J. M., and Carson, D., *J. Roy. Tech. Coll., Glasgow*, **2**, 161 (1930).

It is clear from Dr. Vernon's and from Dr. Macaulay's observations that a variety of surface contaminants can give rise to an apparently heavy 'adsorption' of water vapour. We should expect this to be so since any hygroscopic substance will take up water in this way, and the results quoted are in harmony with our experiments. We find, for example, that if clean metal surfaces are washed with tap water and then dried, there is a large increase in weight when they are exposed to water vapour well below its saturation pressure.

With pure water vapour and with surfaces which have been cleaned by heating *in vacuo*, this is not observed. Nevertheless, the adsorption is appreciable and is measurable: in our experiments (both by direct weighing and by the use of polarized light) it corresponded to about one molecular layer when the relative pressure of water vapour was *c.* 0·7 and about two molecular layers when it was *c.* 0·95. The fact that the adsorption of water on clean surfaces is small is of general interest, since experiments which appear to show heavy adsorption are often quoted as evidence for long-range surface effects.

F. P. Bowden
W. R. Throssell

Research Laboratory for the Physics
and Chemistry of Surfaces,
Department of Physical Chemistry,
Cambridge. May 21.

FORTHCOMING EVENTS

Monday, June 25

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting.

Tuesday, June 26

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Annual General Meeting; Prof. E. E. Evans-Pritchard: "Some Features of Nuer Religion" (Presidential Address).

Tuesday, June 26—Friday, June 29

INSTITUTE OF PERSONNEL MANAGEMENT (at St. Catharine's College, Cambridge).—Conference for Overseas Visitors on "Personnel Management in Great Britain—its Contribution to Productivity".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT AGRICULTURAL ECONOMISTS (three at Bristol and two at Newton Abbot)—The Registrar, The University, Bristol (June 30).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Liverpool (June 30).

ASSISTANT LECTURER IN METALLURGY (probationary)—The Registrar, University College, Singleton Park, Swansea (June 30).

CIVIL ENGINEERS (main Grade) (Ref. E.251/51), and ASSISTANT CIVIL ENGINEERS (Recruitment Grade) (Ref. E.252/51), in the Directorate General of Works in London and the Provinces—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (June 30).

LIBRARIAN (must be a British subject and preferably possess a university degree in physics or chemistry) to take charge of the Association's library, and a PHYSICIST (must be a British subject and possess a good degree in physics) to undertake research on textile materials and processes—The Secretary, Hosiery and Allied Trades Research Association, Thorneywood House, 4 First Avenue, Sherwood Rise, Nottingham (June 30).

SCIENTIFIC OFFICERS (Zoologists) for the Rodent Control Research Section (Ref. G.102/51A), and a SENIOR SCIENTIFIC OFFICER (Chemist) for work relating to the testing and practical development of insecticides (other than fumigants) for use in food stores and similar premises (Ref. F.219/51A), in the Infestation Control Division of the Ministry of Agriculture and Fisheries, Tolworth, Surrey—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (June 30).

MEDICAL STATISTICIAN (candidates must be registered medical practitioners, and have had statistical training, preferably with a university degree and a diploma in Public Health, and with experience in at least two of the following: (1) resident hospital appointment; (2) public health service; (3) school medical service; (4) pathology; (5) general practice; (6) medical research; (7) industrial medicine)—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 4035/51 (July 5).

LECTURER IN MECHANICAL ENGINEERING and a LECTURER IN INORGANIC CHEMISTRY (with an honours degree or equivalent qualification), and a LECTURER IN PHYSIOLOGY for Pharmacy students (graduate preferably with a pharmaceutical qualification)—The Principal, Heriot-Watt College, Edinburgh (July 6).

RESEARCH CHEMISTS (with some research experience in general physical chemistry, or in structural carbohydrate chemistry, or in analytical chemistry) for fundamental work associated with fermentation and with brewing materials—The Director, Brewing Industry Research Foundation, Nutfield, Surrey (July 6).

LECTURER or SENIOR LECTURER IN EDUCATIONAL PSYCHOLOGY in the University Institute of Education—The Registrar, The University, Sheffield (July 7).

ORGANIC CHEMISTS (2) with experience of synthetic research work and modern methods of organic analysis, an ANALYTICAL CHEMIST for the development of new chemical testing methods (experience with explosives essential), PHYSICAL CHEMISTS (13) with experience of plastics, rheology, colloids, kinetics or instrumentation, CHEMICAL ENGINEERS (3) with experience in plant development and design, a PLANT CHEMIST with experience in the control of processes involving high and low temperature gases, CHEMISTS (3) with experience of gas analysis, of gaseous reactions under laboratory conditions or of the control of gases on an industrial scale, and CHEMISTS (2) with experience in examination of water and sewage effluents, at Ministry of Supply Research and Development Establishments near London—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.375/51/A (July 7).

READER IN BOTANY at Makerere College, East Africa—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 7).

RESEARCH DEMONSTRATOR IN MATHEMATICS, to engage in research and to carry out light teaching duties, mostly of a tutorial nature—The Registrar, The University, Sheffield (July 7).

RESEARCH WORKER (with an honours degree in Biochemistry, or its equivalent) for the Asthma Research Council—The Secretary, Wright-Fleming Institute, St. Mary's Hospital Medical School, Paddington, London, W.2 (July 7).

PERREN CHAIR OF ASTRONOMY, tenable at University College (the holder of the Chair will be Director of the University of London Observatory, Mill Hill, but it is not essential that he should be an observational astronomer, and he will be responsible for the organization of teaching and research in the university)—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 9).

SENIOR LECTURER and a LECTURER IN PATHOLOGY, and a RESEARCH ASSOCIATESHIP IN CHEMISTRY, at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (July 14).

BOTANIST (with a good honours degree and with research and other experience in plant breeding, genetics, or horticulture) for fruit-breeding—The Secretary, East Malling Research Station, Maidstone, Kent (July 21).

ENGINEER (Principal Research Officer or Senior Research Officer) (Ref. No. 3423) to initiate and carry out investigations concerned with the properties and behaviour of fibre assemblies and with the problems of processing the fibres, and a SENIOR PHYSICIST (Principal Research Officer or Senior Research Officer) (Ref. No. 3425) to initiate and carry out investigations concerned with the physical properties and behaviour of fibres and assemblies of fibres, for the Commonwealth Scientific and Industrial Research Organization's Wool Textile Research Laboratory, North Ryde, New South Wales—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting appropriate reference number (July 31).

LECTURER IN ECONOMICS (an honours graduate of a British university with appropriate qualifications and experience) at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

UNIVERSITY DEMONSTRATORS (2) IN CHEMICAL ENGINEERING—The Secretary of the Appointments Committee of the Department of Chemical Engineering, Tennis Court Road, Cambridge (August 1).

RITCHIE PROFESSOR OF RESEARCH IN ECONOMICS at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 7).

DEAN OF THE NEWLY ESTABLISHED FACULTY OF MEDICINE for non-European students, at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 1).

ASSISTANT LECTURER IN PHARMACEUTICAL CHEMISTRY (with the Pharmaceutical Chemists' Diploma and/or a degree in science or pharmacy, or equivalent qualification) in the Department of Pharmacy, Plymouth and Devonport College—The Director of Education, Education Office, Cobourg Street, Plymouth.

ASSISTANT LECTURER IN STATISTICS—The Secretary and Registrar, University College, Southampton.

MICROBIOLOGIST (graduate) with research experience—British Food Manufacturing Industries Research Association, Randalls Road, Leatherhead.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Ministry of Agriculture and Fisheries. Fishery Investigations, Series 1, Vol. 5, No. 3: Salmon of the Cheshire Dee. By Dr. J. W. Jones. Pp. 20. (London: H.M. Stationery Office, 1950.) 1*s.* 6*d.* net. [114

Wool Industries Research Association. Publication No. 193: Report of the Director of Research for 1950–51. Pp. 28. (Leeds: Wool Industries Research Association, 1951.) [114

Communications of the Dublin Institute for Advanced Studies. Series A, No. 6: Studies in the Non-Symmetric Generalization of the Theory of Gravitation, 1. By E. Schrödinger. Pp. 28. Series A, No. 7: On the Theory of a Nucleon Cascade. By H. Messel. Pp. iv+103. (Dublin: Dublin Institute for Advanced Studies, 1951.) [114

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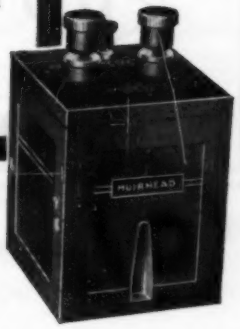

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